12-2018

An Examination of What Motivates Utah Residents to Adopt the Practice of Rainwater Harvesting

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AN EXAMINATION OF WHAT MOTIVATES UTAH RESIDENTS TO ADOPT THE PRACTICE OF RAINWATER HARVESTING

by

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A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF LANDSCAPE ARCHITECTURE

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UTAH STATE UNIVERSITY
Logan, Utah

2018

ABSTRACT

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by

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Utah State University, 2018

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Although most of the earth is covered in water, a very limited amount of that water is fresh water, which is essential to our survival. Therefore, it is imperative that we do all that is possible to conserve and protect our extremely limited water resources, especially in arid regions such as the American West. While there are many ways and means to protecting and preserving our water resources, this thesis focuses on the strategy of rainwater harvesting (RWH) as it is done throughout the state of Utah.

Historically, RWH has not been allowed in states—such as Utah—that follow the doctrine of prior appropriation. However, in 2010, the Utah State Legislature modified long-standing laws to allow residents of Utah to legally harvest up to 2,500 gallons at a time. Since then, many Utahans have adopted the practice. However, the number of Utah residents who are practicing RWH is still a minute percentage of the entire Utah population.

This research included surveying self-identified rainwater harvesters throughout Utah and sought to discover and understand their motivations for practicing RWH. This information has the potential to assist planners, water districts, water managers, cities, state agencies, and legislators in persuading others throughout the state to also adopt the practice. It was found that an emergency supply of water and concern for the environment are the most important motivators for Utah rainwater harvesters. Unsurprisingly, financial savings also had significant influence on harvesters and their decision to practice RWH.

A secondary aspect of the research was to examine Utah State Senate Bill 32, the current laws in Utah concerning RWH. It was found that the current laws are written in a restrictive manner and should be changed and adjusted in order for a greater percentage of the Utah population to be motivated to adopt RWH.

(118 pages)

PUBLIC ABSTRACT

An Examination of What Motivates Utah Residents to Adopt the Practice of Rainwater Harvesting

D. Wayne Honaker

Although most of the earth is covered in water, a very limited amount of that water is fresh water, which is essential to our survival. Therefore, it is imperative that we do all that is possible to conserve and protect our extremely limited water resources, especially in arid regions such as the American West. While there are many ways and means to protecting and preserving our water resources, this thesis focuses on the strategy of rainwater harvesting (RWH) as it is done throughout the state of Utah. RWH is defined as taking the precipitation that falls on our built structures and putting it to good use when it would often otherwise end up in gutters, pipes, and storm drains to be processed and/or disposed of at a distant location. RWH systems consist of several different components including a catchment area (usually, but not always, a rooftop), gutters, a place for storage, and some way of future dispersal and use of the collected water. There are numerous documented benefits to RWH.

Historically, RWH has not been allowed in states—such as Utah—that follow the doctrine of prior appropriation, which strongly defends the case for water rights and affirms that senior water rights should not be infringed upon. According to the law, when someone practiced RWH they were infringing on the water rights of others. However, in 2010, the Utah State Legislature modified these long-standing laws to allow residents of

Utah to legally harvest up to 2,500 gallons at a time without fear of infringement on others' water rights. Since then, many Utahans have adopted RWH. However, the number of Utah residents who are practicing RWH is still a tiny percentage of the entire Utah population.

This research included surveying self-identified rainwater harvesters throughout Utah and sought to discover and understand their motivations for adopting the practice. This information has the potential to assist planners, water districts, water managers, cities, state agencies, and legislators in persuading others throughout the state to also adopt the practice. It was found that an emergency supply of water and concern for the environment are the most important motivators for Utah rainwater harvesters. Unsurprisingly, financial savings also had a significant influence on harvesters and their decision to practice RWH, although they spent considerably less on their RWH systems than is typically spent in other states and countries.

A secondary aspect of the research was to examine Utah State Senate Bill 32, the current law in Utah concerning RWH. It was found that the current laws are written in a restrictive manner and should be changed and adjusted in order for a greater percentage of the Utah population to be motivated to adopt RWH.

ACKNOWLEDGMENTS

I would like to extend appreciation to my advisor, Phil Waite, for providing the opportunity to pursue this research and for his instruction in it. Time spent researching and writing this thesis has expanded my mind and abilities and has been a positive influence in my life and education. The other members of my thesis committee, Dr. Keith Christensen and Dr. Kelly Kopp, have also been instrumental in making sure this thesis was all it could be. I am grateful for their positivity, encouragement, timely correction and advice.

While the rest of the Landscape Architecture and Environmental Planning (LAEP) faculty and staff may not have had as direct a hand in the preparation of this thesis, I count my time under their instruction and company as particularly valuable. Likewise, my colleagues throughout all the LAEP studios have influenced and enhanced my education in ways they may never know but for which I will be forever grateful.

I give special thanks to my family, as well as the family I married into, for their constant support and encouragement throughout my years in graduate school. In addition, I must specifically thank my wife, Heather, for the role she played in getting me started down the path to graduate school in landscape architecture. Her constant love, support, encouragement, and never-ending patience, as well as her motivational pep talks, throughout the long months of graduate school and the process of writing this thesis are the main reasons I have survived. I thank her, and our two daughters, for putting up with the stress, clutter, long days, and late nights of our graduate school experience. Thank you Heather, I would be lost without you!

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CHAPTER I

INTRODUCTION

Every living thing depends on water for survival. Without water, humans can only live for a number of days, but we depend on water for so much more than survival. It is an essential element of almost every part of our lives. Although over two thirds of the earth is covered with water, less than one percent of that water is accessible to us and suitable for human consumption and use (U.S. Geological Survey [USGS] Water Science School, 2016). Therefore, it is essential that we do all that is possible to conserve and protect our extremely limited water resources. This is especially true for areas of the world, such as the western United States, that are naturally drier and even more limited in water resources than other parts of the world. Throughout the history of our current society, a significant amount of effort has been put into developing, managing, and protecting our water resources. Several tools and technologies that have been created in the past several decades and that can be useful in reducing our water use are dual-flush toilets, energy efficient appliances, grey-water recycling, and rainwater harvesting. While all of these tools, as well as several other practices and technologies, are beneficial in reducing water consumption, this thesis focuses specifically on rainwater harvesting (RWH), and that in the state of Utah.

Rainwater Harvesting in Utah

Throughout the world, rainwater has historically been seen as a valuable source of water and harvesting it has been a natural behavior. Unfortunately, as water law in many

western states developed, RWH became an illegal activity due to the principle of appropriation and water rights (water law and how it relates to and affects RWH will be explained in further detail in the next chapter). In the past few decades, and in part as a result of water shortages throughout the West, RWH has received more consideration and has, once again, been legally permitted and even promoted throughout several western states. For Utah—which has been affirmed as the second driest state in the nation (Osborn, 2018)—this came in 2010, when the state legislature passed Utah Senate Bill 32 which modified the state water laws to allow residents to harvest up to 2,500 gallons of rainwater (see Appendix D). Since that time, many residents of Utah have adopted RWH. The present research is an attempt to discover and understand the motivations of these individuals and what specific factors have caused them to adopt the practice of RWH. It is anticipated that with this information, proponents of RWH throughout the state will be better able to promote the practice to the rest of the population in Utah.

Previous Work

Nationally and internationally, RWH is growing in popularity (Lohan, 2008). An extensive body of research has been done, and continues to go forward, throughout the world on RWH, its benefits and usefulness, and even its failings and problems. Some of this research is based on the drier areas of the world but only a small portion of it is focused on the American West. Utah encompasses a very unique range of climatic elements but has received extremely sparse research efforts in relation to RWH and how it can best be utilized and adapted throughout the state. This is likely due to the fact that

RWH was illegal in Utah until 2010. However, there is some rainwater collection information aimed at Utahns through USU Extension which has readily available information for small-scale RWH. Also, a number of resources, while tailored to other locations, could be usefully applied to locations in Utah.

Two of these resources – both by Brad Lancaster—address rainwater harvesting methods and technologies for dry land areas (Lancaster, 2007, 2013). Like Lancaster, Ludwig (2005) identifies a variety of techniques for harvesting and storing storm water in Southern California, but only includes one page on freeze protection strategies, which are essential to remember in Utah. There are, in fact, very few resources describing rainwater collection strategies for cold climates (Kinkade-Levario, n.d.). Several resources (Condon, 2010; Kinkade-Levario, 2007; Sipes, 2010; Venhaus, 2012) indicate the key role rainwater harvesting plays in the creation of sustainable communities and sustainable sites. Two resources, namely *Design for Water* (Kinkade-Levario, 2007) and *The Texas Manual on Rainwater Harvesting* (Krishna, 2005) are particularly instructive and provide technical details and information on actual installation methodologies. One study (Greenberg, 2015) did focus on Utah as well as the other four-corners states of Arizona, Colorado, and New Mexico and examined factors that either enable or constrain RWH practices and policy in those states. According to a review of the literature, which will be explained further in the next chapter, this is the first study to examine the motivations of the early adopters of RWH in Utah specifically.

Potential Contribution of this Research

As mentioned above, water is a fundamental part of our everyday lives and managing as well as protecting our water resources is becoming an ever larger issue throughout the world that deserves our efforts and discussions in order to find applicable and useful solutions to all aspects of our water use—both in terms of quality and quantity. The usefulness and benefits of RWH is just one small part of that much larger discussion. Similarly, the research explored in this thesis—to understand the motivations of rainwater harvesters throughout Utah—is just the beginning of the research needed on this topic. The overall and enduring objective of this research is—and that of future research should be—to determine what the perceived barriers are to RWH in Utah and how those barriers can be minimized and/or overcome. Additionally, it should seek to outline how best to promote and encourage RWH to the larger population in Utah. Much more work and research will need to be done before RWH will reach its full potential as an important conservation option in Utah. "Robin Carbaugh, with the Utah chapter of the U.S. Green Building Council, said rain harvesting is a 'baby step' that could lead to more enthusiastic water conservation attitudes in Utah" (McKellar, 2015). The hope is that this is the case, and that this research will encourage the ongoing discussion of RWH in Utah that is needed among researchers, elected officials and the public in order for the practice of RWH to be more fully adopted. Additionally, the laws and regulations concerning RWH should be reviewed and modified in order to better promote the practice.

CHAPTER II

BACKGROUND AND LITERATURE REVIEW

This chapter provides context for the present research of examining the motivations of rainwater harvesters in Utah. The chapter begins with an explanation of why water conservation is important in the Utah climate and how RWH can be a useful tool in conservation. This is followed by a description of RWH, the components of a RWH system as well as the benefits that a typical homeowner could realize by installing one. The second half of the chapter is a review of the legal aspects of RWH. It reviews water law and how RWH is affected by the law, the history of RWH in Utah, and what the current laws allow. The chapter concludes by describing the goals of the current study and how it fits into this framework.

Importance of Water Conservation in Utah

Like many other places in the western U.S., Utah is experiencing growing pressures on its scarce water resources. The main factor that causes Utah and the intermountain west to be so much drier than other parts of the country is topography. While much of the eastern U.S. is generally lower in elevation and closer to a coast, many parts of the intermountain west are further from the ocean, considerably higher in elevation, and the mountain ranges along the west coast make it difficult for coastal storms to penetrate deeply into the continent. Although the influence of topography on the Utah climate is fairly constant, several other lines of force are converging to cause and exacerbate water shortages.

1. Utah has an existing pattern of excessive water use: though Utah is the second driest state in the nation it has the highest per capita use of water (McKellar, 2015). One study found that Utah uses 248 gallons per person per day compared to the national average of 155 gallons (USGS, 2010). As much as 82% of all of Utah's water is used for agricultural purposes (Hollenhorst, 2015). Unfortunately, drinking water accounts for only a tiny fraction of total consumption (Thomas, 1998). Up to 60% of Utah's treated domestic water—that which has been expensively processed and made safe for drinking—is being poured back out into the landscape (Hollenhorst, 2015).

2. Utah has one of the fastest growing populations in the country and anticipates doubling the current population—bulging to six million people—by the year 2050 (Utah Department of Health [UDOH], 2017). Salt Lake City is one of the 10 fastest growing cities in the U.S.[1] This doubling of the population will not only increase the demand on our limited supply of water but will also put added strain on the water infrastructure and resources needed to get water to where people are. Much of the west—including Utah—has been developed "without regard to where water is naturally abundant, or perhaps in inverse ratio to abundance" (Fort, n.d.).

3. The American west is facing a cyclical return to drier climate conditions which will exacerbate shortages caused by an ever increasing population (Fagan, 2008; Ingram & Malamud-Roam, 2013).

4. Over-all global climate change is altering how, when, and where precipitation falls in the West (Ingram & Malamud-Roam, 2013). Currently, most of the water supply in the West comes from melting snow during the spring and early summer. If climatic shifts result in a change from winter storms to more spring and summer rains or in a decrease in the amount of spring runoff, there will be less water available for storage in the network of western reservoirs (Diaz & Anderson, 1995; McCabe, Wolock, Pederson, Woodhouse, & McAfee, 2017).

5. "Fossil" water sources, or deep aquifers, are being drained faster than they are replenished (Thomas, 1998). The mining of the aquifer—taking more water out than is being replenished—in the Cedar Valley of southwest Utah has caused fissures in the earth to appear in developed areas, causing significant damage to homes and lots. The mining has lowered the water table by as much as 114 feet since 1939 (O'Donoghue, 2014).

[1] Eight of the 10 fastest growing cities in the U.S. are in the West. Additionally, 86% of all westerners live in or near cities (Fort, ND).

So, while water supplies are decreasing—or at the least becoming more erratic in their availability—the population of users demanding water is increasing. Utah is rapidly moving to a point where "climate change and water scarcity [will be] seen as the main physical constraints on future development" (Thomas, 1998). Kjelgren, Rupp, and Kilgren (2000) agree, stating that because the majority of the population in Utah and other western states is "concentrated in rapidly growing urban areas, water is critical in supporting those populations and can potentially govern future growth."

A community in northern Utah has already begun to experience this. Mendon, in Cache County, has recently been forced to issue and then extend a moratorium on development because they have been unable to provide adequate high quality water to current and potential residents (Dolan, 2017). Another community—Torrey Utah, in the southern part of the state—has also experienced water shortages. The pipeline that supplies Torrey's storage tank with water from a spring is 15 miles long and is often damaged by flooding and erosion. An additional problem that Torrey regularly experiences is in the summers when the population swells with tourists and summer residents—the storage tank doesn't have the capacity to keep up with demand for water. When this occurs, the town has no choice but to employ water trucks to supply their system. According to Torrey's mayor, the system has struggled since it was first installed in 1968 and likely will for years to come (Penrod, 2017). Additionally, several communities in Utah County have begun encouraging and then enforcing water conservation when they see water shortages coming (Allred, 2013). Perhaps one of the most well-known water issues in the state is currently ongoing in St. George and

Washington County. The area is rapidly growing and the plans to expand and allow for population growth include building a massive pipeline from Lake Powell to Washington County (Schneider, 2017). If this continues to move forward, it would come with major impacts and implications not only for that area but also for the rest of the state as well as the other down-stream states.

With water shortages and supply issues occurring regularly throughout the state, it is obvious that these aren't problems that are easily solved and eliminated. Only by significantly increasing our efforts to conserve and wisely manage our water resources will we be able to provide a sufficient supply to the growing population in the future.

Potential Contribution of Rainwater Harvesting to Water Conservation

With water already in limited supply and with the ever increasing demand, a significant amount of effort is being placed on finding additional sources of water and conserving the water we have. RWH is one way to do this and "rainwater harvesting systems are currently gaining popularity as many communities promote sustainable development" (Kinkade-Levario, 2007). In fact, "Many domestic RWH techniques have been pioneered in semiarid areas having a very long dry season, not because these areas favour harvesting but because they so strongly disfavour all alternatives" (Thomas, 1998). A number of states throughout the West are not only allowing their residents to legally harvest rainwater, but are also actively promoting it (Loper, 2015). Kinkade-Levario states further:

> This potential supply of water is especially important in all arid and semi-arid regions [such as Utah] where rainfall is neither frequent nor reliable. Collecting

> the water that falls onto a designated site, then retaining that water and/or using water that is generated on site for on-site needs can be important for the sustainability of any design or development of a localized area. Applied consistently over the course of several projects, this water supply can have regional importance for the conservation of limited ground and surface water supplies.

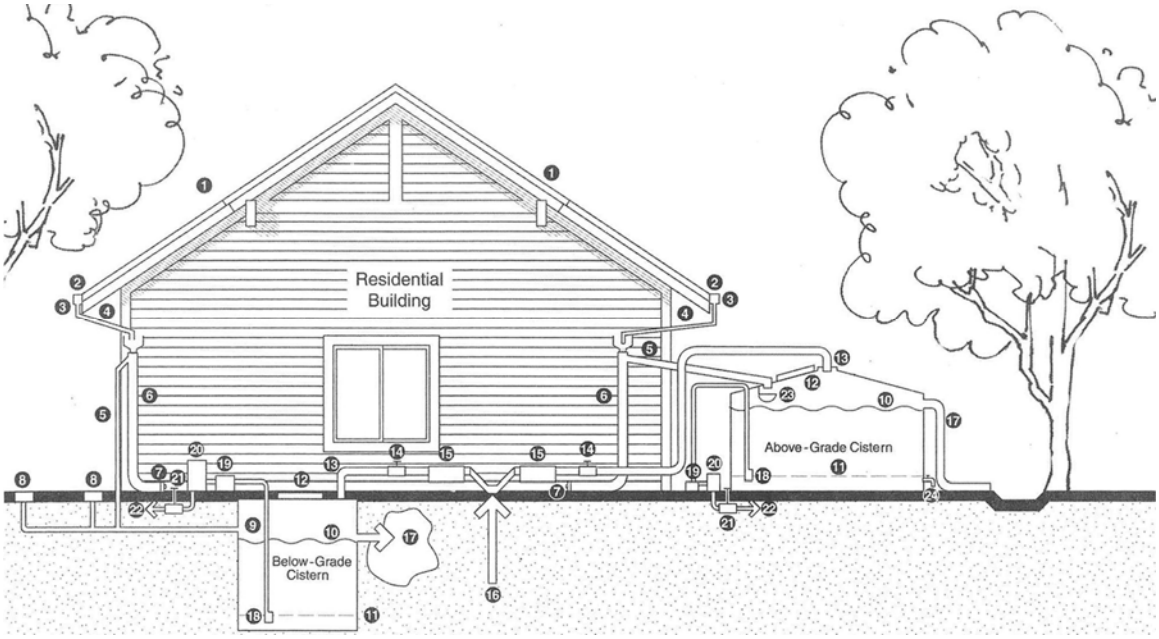
In a village in southern Gujarat, India, rainwater harvesters have begun to see the regional impacts that Kinkade-Levario (2007) describes. Before the village leaders implemented RWH strategies, the village population was shrinking as wells dried up and people moved to other locations because of the lack of water. After implementing RWH techniques, the water table in the area has risen, wells that were beginning to dry up are again flowing, and many of the residents have been able to increase their standard of living as a result of "catching the rain" (Pearce, 2004, 2006). Kinkade-Levario is correct that RWH is gaining popularity but it will need to be more widely adopted and more significantly promoted in Utah if it is to result in large regional impacts similar to those experienced in India.

What is Rainwater Harvesting?

"Simply stated, rainwater harvesting (RWH) is the capture and storage of rainwater and snowmelt at the location where it occurs" (Courtney, 2008). This can be done for a number of purposes including "landscape irrigation, drinking and domestic use, aquifer recharge, and storm water abatement" (Krishna, 2005). RWH is taking the precipitation that falls on our built structures—not only rooftops but other impervious surfaces such as roads, sidewalks, and driveways—and putting it to good use when it would often otherwise end up in gutters, pipes, and storm drains to be processed and/or

disposed of at a distant location. In some locations, rainwater is stored in open ponds or very large tanks with enough capacity for several thousand gallons (Kinkade-Levario, 2007). In Utah, however, harvesters are limited by state law to collecting and storing a maximum of 2,500 gallons at a time in some type of storage tank (Utah SB 32, 2010). Figure 1 illustrates how a typical residential rainwater harvesting system could be set up and how it would function.

Domestic rainwater harvesting (DRWH) is not a new technology or a new idea; in fact, it is quite old. "Archeological evidence attests to the capture of rainwater as far back as 4,000 years ago, and the concept of rainwater harvesting in China may date back 6,000 years" (Krishna, 2005). Thomas (1998) states that "rainwater harvesting is an old technology now being given a new look." He continues by saying that throughout the world, water reaches buildings in one of three ways. It can be piped, physically carried from wells, springs, lakes, and rivers, or collected as rainwater. "Rainwater harvesting has more of a past and a future than a significant 'present'. Its use has diminished due to the world-wide expansion of the first two alternatives above" (Thomas, 1998). In the past, DRWH was seen as the natural thing to do. People found an available and easily obtained source of water—the rain—and they were quick to take advantage of it. Unfortunately, as our ability to move water over great distances has increased, RWH has moved into the background as a last resort. Furthermore, with the creation and development of water law throughout the western U.S., many states turned to forbidding the practice. Only fairly recently have some states began adjusting their laws to once again allow, and in a few cases, promote or require the practice of DRWH (Loper, 2015).



NOTE: Both above-grade and below-grade cisterns are shown. For residential systems, either may be appropriate. It is not necessary to have both types of systems. Cistern size and catchment area should be balanced for maximum accumulated storage. Not all site rainfall runoff needs to be directed to cistern, only the quantity required to maintain the proposed landscape irrigation budget.

1. Rooftop collection.
2. Gutter with leave screen if building is adjacent to trees.
3. Five- to six-inch gutters, sized per local plumbing code.
4. Downspout sized per local plumbing code, sediment trap for ground-level catchment or direct to cistern.
5. Pipe to cistern, typically 4-inch diameter schedule 40 PVC pipe.
6. Debris and sediment interceptor, first-flush device.
7. Screw-off end cap for cleaning.
8. Catchbasin for paved/hard surface ground-level runoff collection, with sediment trap.
9. Rainwater inlet, inlet to cistern must be a minimum of 10 inches below top of cistern. An inflow smoothing filter may be appropriate at this location depending on proximity of rainwater inlet to irrigation supply filter. The smoothing filter will slow rainwater inlet turbulence that may disturb the fine sediment settled on the bottom of the cistern.
10. Maximum water level to be 12 inches below top of cistern.
11. Minimal level of water to maintain priming in landscape irrigation pump (approximately 12 inches), Level of water to be determined by engineer or irrigation specialist.
12. Twenty-four-inch access for cleaning.
13. Alternate water supply, must not obstruct the 24-inch access. Alternate water supply may be proposed for a cistern manual-fill option for droughts and plant establishment periods when additional water is required. Alternate water supply may also be automatic for fill option when rainwater supplies are inefficient.
14. Typical valve.
15. Atmospheric vacuum breaker.
16. Alternate water source, possibly domestic or municipal supply.
17. Cistern overflow (same size as inlet) to a dry well or gravity outlet to landscape basin if site conditions allow. An additional option would be to outlet to an adjacent flood retention underground storage pipe that is tied to a dry well. Cistern overflow must be a minimum of 12 inches below top of cistern to avoid contamination of alternate water supply, or be 6 inches below any debris strainers in an above-grade cistern.
18. Landscape irrigation supply filter with automatic shutoff to maintain priming in pump if water falls below minimum level in cistern. Locate filter a minimum of 6 inches from cistern bottom to avoid settled fine sediment.
19. Optional sand filter.
20. Landscape irrigation pump and pressure tank.
21. Typical valve.
22. Water supply line for irrigation system.
23. Removable leaf and debris strainer basket.
24. Hose bib for draining cistern.

Figure 1. Typical components of a residential building RWH system for landscape irrigation (copied with permission from *Design for Water*: see Appendix E).

As Thomas implied, we will likely begin to see a larger focus on RWH in the future as individuals and governments search for ways to be more efficient and conservative with our increasingly scarce water resources.

Rainwater Harvesting Systems

Rainwater harvesting systems can range from very simple and straightforward—such as a plain bucket—to very large and complex, involving many components. Thomas (1998) explains that there are three key system elements to any rainwater harvesting system: (i) a collection surface, (ii) guttering, and (iii) a water store. In her book *Design for Water*, Kinkade-Levario (2007) expands these elements further into six basic components.

1. Catchment area: the surface upon which the rain falls. It may be a roof or impervious pavement and may include landscaped areas.
2. Conveyance: channels or pipes that transport the water from catchment area to storage.
3. Roof washing: the systems that filter and remove contaminants and debris. This includes first-flush devices (roofs are often dusty and contain a certain amount of pollutants. Therefore, the first several gallons of any rain event which wash away the pollutants—the first-flush—should be diverted away from the storage tank).
4. Storage: cisterns or tanks where collected rainwater is stored. Storage tanks can be made of a number of materials from plastics to metal to concrete.
5. Distribution: the system that delivers the rainwater, either by gravity or pump.
6. Purification: includes filtering equipment, distillation, and additives to settle, filter, and disinfect the collected rainwater.

Many RWH systems do not have all of these components and depending on the intended use of the collected rainwater, may not need them. For instance, if the water is

intended for non-potable uses, roof washing and purification of the stored water will be mostly unnecessary. However, in many parts of the West, rainwater harvesters are using their systems for culinary and other potable uses. In these cases, when it would be important to measure and monitor water quality, having some way to purify the water is essential (Krishna, 2005). As Courtney (2008) states, "The simplest rainwater harvesting system doesn't have to include storage—just a rooftop and gutter system. Many homeowners actually practice this by extending downspouts from gutters and directing rain and snowmelt across lawns and gardens." Although, it could be argued that having a rooftop with a gutter system isn't really harvesting rainwater but merely redirecting it. The obvious benefit, especially in arid environments, that is gained by practicing true RWH by adding storage capacity to the system is the ability to collect the water during large rain events and then prolong its use over an extended period of time.

Financial Costs of Rainwater Harvesting Systems

Similar to their size and scope, RWH systems vary greatly in the cost required to install one. The larger the system the higher the cost will be. An extremely small above-ground system could be obtained and installed for a few hundred dollars (excluding the costs of gutters which are often installed on homes whether the homeowner plans to harvest rainwater or not). Costs range from a low of about $0.50 per gallon for large fiberglass tanks up to $4 per gallon for welded steel tanks (Krishna, 2005). The storage tank and its installation are by far the most expensive components of any substantial rainwater harvesting system. "Typical residential underground cisterns run around

$10,000 to $15,000 (installed)" (Courtney, 2008). Most cost is incurred by the size of the tank, its material—that must enable it to withstand the pressures of being buried—and the excavation to place it underground. Fairly large residential systems can also be placed above ground, provided there is space for it and the ground will support it. Even large above-ground systems can be significantly less expensive than underground systems.

Spatial Requirements and Aesthetics of Rainwater Harvesting Systems

Similar to the cost of any given rainwater harvesting system, the space required by a system will depend largely on the size of the storage tank. Small systems that use a typical barrel for storage will only require a few square feet close to the gutter downspout. A 2,500-gallon tank, the largest size allowed by law in Utah, could be about 6 feet by 12 feet either upright or horizontal (Krishna, 2005). Manufacturers have developed storage tanks and systems that work well underground as well as tanks that fit a number of different situations and can be made to be as aesthetically pleasing as possible. The two main reasons for burying a RWH storage tank are for aesthetic considerations and to save space above ground (Krishna, 2005).

For homeowners who plan to install a RWH system above-ground but have concerns with the aesthetics of a large standard tank, there are other options available. Tanks can be found in varying sizes, dimensions, and colors that can allow them to fit into a number of locations and settings. They can also be screened with built structures or vegetation to increase their aesthetic appeal. Each harvester has the ability to customize their storage tank to the degree that they prefer.

Potential Amount Collected in a Typical Rainwater Harvesting System

The USU Extension website states that "a half-inch of rain on a 1,000 square foot roof produces approximately 280 gallons of water! Even in a dry state like Utah, up to 5,000 gallons of storm water runoff could be captured from an average roof" (USU Extension, 2016). Nick Schou, the conservation director for the Utah Rivers Council said "an average household in an arid climate can save about 10,000 gallons a year" (McKellar, 2015). This may not sound significant when one considers how much water a typical residence uses—especially in the landscape—and, in truth, RWH will likely never be able to completely replace the current supply of water from other sources. However, RWH is beneficial and can be significant; one study found that, when paired with water-wise landscaping, RWH could provide almost half of the supply needed by the landscape (Courtney, 2008).

"In theory, approximately 0.62 gallons per square foot of collection surface per inch of rainfall can be collected. In practice, however, some rainwater is lost to first flush, evaporation, splash-out or overshoot from the gutters in hard rains, and possibly leaks" (Krishna, 2005). The material of the collection surface can make a difference as well, and smoother collection surfaces are typically better. "Rough collection surfaces are less efficient at conveying water, as water captured in pore spaces tends to be lost to evaporation" (Krishna, 2005). Following is the RWH formula as given by The Texas Manual on Rainwater Harvesting:

1 inch of rain × 0.62 gallons × roof area = amount of water collected
1 inch of rain × 0.62 gallons × 1,000 square feet = 620 gallons
1 inch of rain × 0.62 gallons × 2,500 square feet = 1550 gallons

Table 1 shows examples of specific locations in Utah, the average precipitation, and how many gallons of rainwater could potentially be harvested in those locations.

Benefits of Rainwater Harvesting

Design for water (Kinkade-Levario, 2007) includes a list of the benefits of RWH.

Table 1

Precipitation Data for Selected Utah Cities

	Average precipitation per month (inches) and RWH potential (gallons)							
City	Jan.	Mar.	May	July	Sept.	Nov.	Avg. annual precipitation (in.)	Annual RWH potential (gallons)
Logan	1.61	1.73	2.24	0.75	1.42	1.61	18.53	
1000 sq. ft. collection surface	998	1,073	1,389	465	880	998		11,489
2500 sq. ft. collection surface	2,496	2,682	3,472	1,163	2,201	2,496		28,722
Moab	0.63	0.83	0.71	0.98	0.87	0.75	9.49	
1000 sq. ft. collection surface	391	515	440	608	539	465		5,884
2500 sq. ft. collection surface	977	1,287	1,101	1,519	1,349	1,163		14,710
Salt Lake City	1.46	2.20	2.09	0.59	1.54	1.77	18.58	
1000 sq. ft. collection surface	905	1,364	1,296	366	955	1,097		11,520
2500 sq. ft. collection surface	2,263	3,410	3,240	915	2,387	2,744		28,799
St. George	1.07	0.93	0.39	.067	0.60	0.64	8.25	
1000 sq. ft. collection surface	663	577	242	415	372	397		5,115
2500 sq. ft. collection surface	1,659	1,442	605	1,039	930	992		12,788
Wendover	0.31	0.43	0.83	0.28	0.48	0.28	4.76	
1000 sq. ft. collection surface	192	267	515	174	267	174		2,951
2500 sq. ft. collection surface	481	667	1,287	434	667	434		7,378

Note. data collected from "U.S. Climate Data," 2017 & the "Western Regional Climate Center," 2016.

Those applicable to Utah are as follows:

1. It provides a self-sufficient water supply located close to the user.

2. It reduces the need for, and hence the cost of, pumping groundwater.

3. It provides high-quality soft water that is low in mineral content.

4. It augments the supply and improves the quality of groundwater when it reaches the aquifer after it has been applied to the landscape or crops.

   As evidenced in Gujarat, in the village in India mentioned earlier, it is possible to raise the water table when rain is collected on a community wide scale (Pearce, 2004, 2006).

5. It reduces and may even eliminate soil salts as it dissolves and moves the salts down through the soil.

6. It mitigates urban flooding and, as a result, reduces soil erosion in urban areas.

7. Rooftop rainwater harvesting systems are easy to construct, operate and maintain.

8. Occasionally, there are economic advantages such as rebates from municipalities for a reduction in use and dependency on municipal water. *In 2015, the city of Murray and Salt Lake County provided barrels intended for RWH to their residents and other Utahans at discounted prices. "Hays County [Texas] grants a property tax exemption from county taxes for the value of the rainwater harvesting system"* (Krishna, 2005).

The Texas Manual on Rainwater Harvesting (Krishna, 2005) also lists the following benefits of RWH (some are similar to those listed by Kinkade-Levario):

1. The water is free; the only cost is for collection and use.

2. The end use of harvested water is located close to the source, eliminating the need for complex and costly distribution systems.

3. Rainwater provides a water source when groundwater is unacceptable or unavailable, or it can augment limited groundwater supplies.

4. The zero hardness of rainwater helps prevent scale on appliances, extending their use; rainwater eliminates the need for a water softener and the salts added during the softening process.

5. Rainwater is sodium-free, important for persons on low-sodium diets.

6. Rainwater is superior for landscape irrigation.

   Because it hasn't been processed to the extent that potable water often is, rainwater carries more nutrients that plants need to thrive.

7. Rainwater harvesting reduces flow to stormwater drains and also reduces non-point source pollution. The current norm in storm water management is to collect it, pipe it and dispose of it as quickly and as efficiently as possible. Strassberg and Lancaster (2011) state "The infrastructure designed to drain large-capacity events all too often drains all events, including the smaller more common ones. This is considered dehydration infrastructure." They also point out that "we can begin to manage water by slowing, spreading, and cycling more of its flow instead of paving, piping, and polluting it." One of the best ways to slow down, spread, and cycle water is RWH. Nick Schou of the Utah Rivers Council, said that RWH is "beneficial for water quality because when we harvest the rain off of our roofs, less water scours our streets and gutters, picking up urban pollutants which are washed into our waterways and lakes" (McKellar, 2015).

8. Rainwater harvesting helps utilities reduce the summer demand peak, and delay expansion of existing water treatment plants.

9. Rainwater harvesting reduces consumers' utility bills. Although water in Utah is actually quite affordable, and much of the state is graced with extremely inexpensive secondary water, the iUtah survey completed in 2015 found that 63.24% of Utahans are either concerned or very concerned about the high cost of water (iUtah, 2015). Because of its limited potential, people might say that investing in a RWH system doesn't make financial sense. The cost of a storage tank and its installation as well as maintenance costs in both time and capital can be fairly significant when compared with often lengthy return on investment periods. However, HarvestH20.com provides an alternative view of RWH and how it can make financial sense:

   Another way to determine if a system makes good financial sense is to compare it to other investment alternatives.

   Which is a better investment: paying $15,000 for a rainwater system that yields $1200 a year in savings, or putting that money in a money market account bearing 4% interest a year?

   A 4% interest-bearing account would yield $600 a year on your $15,000 investment, whereas your rainwater system would yield $1,200 a year. To put it another way, a $1,200 annual yield on a $15,000 investment is equivalent to

> an 8% return.
>
> It is currently unlikely to find a low-risk, interest-bearing investment that returns 8% a year. And the return on a rainwater system will only improve over time as utility water rates rise.
>
> So...installing a rainwater harvesting system is often simply a good investment (Hammerstrom & Pushard, 2017).

The benefits realized through RWH will likely vary from one harvester to another and will depend on their site and climatic conditions. One aim of this research is to determine what benefits the rainwater harvesters in Utah feel they gain through their own RWH systems.

Water Law, History, and the Focus of the Current Study

Doctrine of Prior Appropriation

The doctrine of prior appropriation—often stated as "first in time, first in right"—protects senior water rights (Courtney, 2008). If someone begins using the water before another, that action establishes their right to use the water first. This form of water law is used in most of the western states and differs quite a bit from the "riparian rights" that are used more often in the eastern states. Riparian law affirms that if one has access to a river or stream, they have the right to use the water in it regardless of when they began using the water. One result of appropriation is an often-quoted axiom of the west that says "Water flows uphill to money." All economic development decisions hinge on the availability of water rights, and, therefore, the transfer of water rights tends to be toward those entities in positions of economic power (Lohan, 2008). Because of the intense scarcity of water in the west, the owner of a water right can do just about what they

please in terms of how they use the water and how that water can be used to support development. Without water rights, on the other hand, one is fairly limited with what can be done with or on the land, which can significantly affect land values. Consequently, water rights—and anything that might infringe on them or even appear to infringe on them—are taken very seriously. Historically, the laws of states that adhere to prior appropriation, which are most of the states in the West, viewed RWH as an infringement on water rights (Courtney, 2008; Ferguson, 2012).

How Rainwater Harvesting is Affected by Water Law

In the appropriation system, "All precipitation is assumed to ultimately contribute to stream flows and is part and parcel of the water that existing water rights are entitled to" (Courtney, 2008). Therefore, according to many western states' laws that adhere to prior appropriation, someone who harvests rainwater is infringing on downstream water rights. However, a study in Douglas County, Colorado found that in undeveloped areas, 97% of rainwater never makes it to rivers and lakes; instead it is taken up and utilized by the native vegetation. In dry years—when senior water rights would be most important—"none of the precipitation returned to the stream or ground water" (Courtney, 2008). With this in mind, it is difficult to claim that by practicing RWH, one is actually infringing on senior water rights. If native vegetation keeps rainwater from running downstream on undeveloped land, nothing is changed by harvesting the rainwater following development.

Several western states have started to realize this and have begun allowing RWH.

In certain cases, some places have even begun requiring RWH. “Santa Fe County, New Mexico, passed the precedent-setting regulation requiring RWH systems on new residential or commercial structures of 2,500 square feet and larger” (Krishna, 2005). While many states in the west, including Utah, now allow RWH, they do so from a regulatory standpoint. Texas is the single state that promotes and actively encourages the practice of RWH (Loper, 2015). The language in The Texas Manual on Rainwater Harvesting (Krishna, 2005) is quite different than the typical language heard in other states’ laws concerning RWH. The manual explains numerous aspects of RWH, such as system components, water quality and treatment issues, calculating demand and required capacity, and best management practices for installing and maintaining a RWH system. While some of the information in the manual is specific to Texas, much of it—including the topics just mentioned—could be quite useful for other locations, such as Utah, where fewer local resources are available.

Utah State Laws Concerning Rainwater Harvesting

With the ratification of Utah Senate Bill 32 in 2010, the Utah legislature modified long-standing laws that had prohibited the domestic collection and storage of rainwater (Utah SB 32, 2010). Residents of Utah are now legally permitted to harvest rainwater, but, there are a few stipulations that they must comply with. First, if someone wishes to store rainwater in an underground cistern, they may do so as long as they have only one cistern and if its capacity is no greater than 2,500 gallons. They must also register their harvesting activity with the state engineer, which is done through the Utah Division of

Water Rights (DWRi). In registering, residents are asked to provide their name, the total capacity of their RWH system, and the address or another suitable description of the location where precipitation is to be captured and stored (Utah SB 32, 2010).

Conversely, if citizens wish to store their harvested rainwater in an above-ground system, they may do so as long as they have no more than two (2) containers and as long as neither of those containers exceeds a capacity of 100 gallons. In the section of the law that discusses such above-ground storage containers, there is no mention of registering with the state as in the section on storing rainwater in a below-ground cistern. Therefore, as the law reads, those who are storing rainwater above ground are not required to register, but they are also only legally permitted to harvest up to 200 gallons. As will be shown later, many of those who are currently practicing RWH in Utah either do not understand the law or don't know that these stipulations are in place; many people are storing their harvested rainwater in above-ground tanks that are well over the 100-gallon limit that the law specifies.

Following this change in the legislation to allow RWH, a few organizations and municipalities throughout the state took action to try to encourage RWH. For example, the city of Murray and Salt Lake County offered barrels for the purpose of RWH to their residents at discounted prices and several people took advantage of the promotion (McKellar, 2015). Also, the USU Extension website includes information and videos on RWH in Utah (USU Extension, 2017a) and a few places, such as the Jordan Valley Water Conservancy District and The Utah House (USU Extension, 2017b), have installed demonstration RWH systems that residents can visit and examine for ideas for their own

RWH system. As a result of the modification to the law and the various promotional efforts throughout the state, there are currently around 1,000 people who have registered their RWH activity with the DWRi. Unfortunately, there are likely many others who have chosen not to self-report their RWH activity or who are unaware of the requirement to register.

Diffusion of Innovation Theory

The diffusion of innovation theory developed by Everett Rogers in 1962, states that when any type of innovation is introduced into a society, 2.5% of the population will be the innovators, or those who promote or introduce the innovation. Those who are first to accept and embrace the innovation are known as the early adopters and will comprise 13.5% of the population. The next groups are the early majority and the late majority, each comprising 34% of the population. The last category, those who are the last to embrace an innovation are termed laggards. This group includes the remaining 16% of the general population. The Diffusion of Innovation Theory is shown graphically in Figure 2. The timeframe to full adoption of an innovation will depend on the innovation itself. Some innovations will be adopted fairly rapidly while others will take significantly more time. It is recognized that RWH in Utah is an innovation that will take a fair amount of time for full adoption to be realized.

According to the U.S. Census Bureau there was close to one million households in Utah in 2015 and the owner-occupied housing rate was 69.5% (U.S. Census Bureau, n.d.). If we assume that only those who actually own their homes would adopt the practice of RWH (which, admittedly, may not always be the case), then there would be

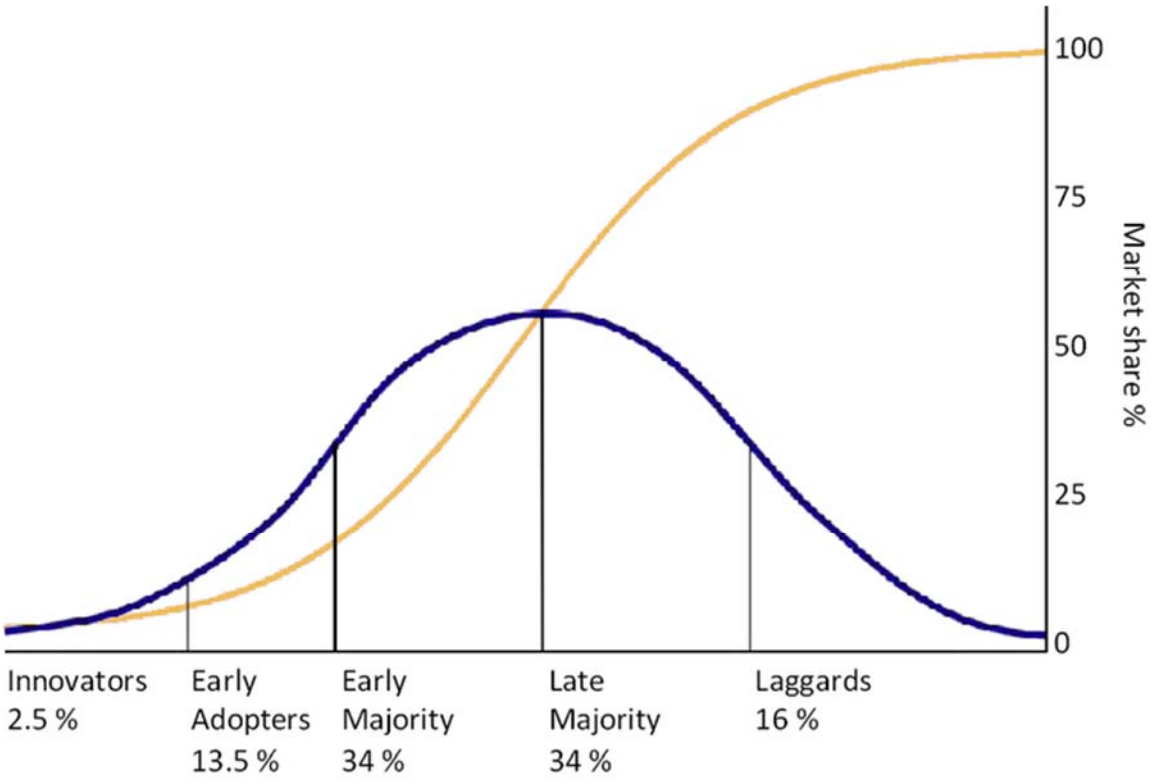


Figure 2. Diffusion of innovation theory (Rogers, 1995); image retrieved from Wikipedia February 20, 2018. With successive groups of consumers adopting the new technology (shown in blue), its market share (yellow) will eventually reach the saturation level.

roughly 695,000 potential adopters throughout the state. By applying the diffusion of innovation theory to RWH in Utah, we find the early adopters would amount to 93,000 households. If this is accurate and it is assumed that enough time has elapsed since the ratification of SB 32 for Utah to have moved to that point in the diffusion of RWH, the DWRi should have roughly the same number (approximately 93,000) of registered harvesters. However, as stated above, there are only around 1,000 people registered with the DWRi. So, obviously, sufficient time has not been allowed for all 93,000 households to adopt and implement RWH. It is at this crossroads that this research is situated. Because the actual number of registered harvesters is so minuscule in comparison to what

diffusion of innovation theory says should exist, this study is an attempt to discover the motivations of those who have adopted RWH thus far. Targeting their motivations is a way of learning what could be done to encourage more Utahans to adopt the practice and therefore accelerate and augment the diffusion of this important innovation throughout the state.

Previous Studies on Motivations to Practice Rainwater Harvesting

In studying RWH in the four-corner states of Arizona, Colorado, New Mexico, and Utah, Greenberg (2015) found that RWH "might be enabled by community acceptance, monetary incentives and impact on water supply" and might be constrained by cost and political barriers. Others have also referenced monetary incentives and cost restrictions. The Texas Manual on RWH states: "To determine whether a municipal utility should consider offering a rebate or financial incentive to stimulate the use of rainwater harvesting, benefits and costs must be presented on an economic basis" (Krishna, 2005). In addition, "minimizing tank costs must be the major objective of any organization working to promote harvesting" (Thomas, 1998). It appears that although there are several significant benefits to RWH, the one that is most likely to catch people's attention and encourage them to adopt RWH, according to the literature, is the potential financial savings they could realize. A Utah example of the use of monetary incentives cited by Greenberg is the promotion offered by Salt Lake County and the city of Murray mentioned above. Several people began harvesting rainwater when the storage tanks were offered at discounted prices (McKellar, 2015).

It is very evident in Utah how political barriers could discourage people from practicing RWH. Utah is the only state that limits the amount of water that can be collected (Loper, 2015), thus limiting the benefits that harvesters could potentially receive. Also, the way the current regulations concerning RWH in Utah are written, if an individual wants to harvest more than 200 gallons they must have a larger tank—that is to say *one* larger tank. Rainwater harvesters are prohibited from having more than two small tanks and "any one covered storage container [must not be] greater than 100 gallons" (Utah SB 32, 2010, p. 32). If this regulation were to be rewritten so as to allow harvesters to determine for themselves the configuration and size of their system, it would allow greater flexibility with regard to their investment and installation timeline. It would likely encourage more people to adopt the practice of RWH. Thomas (Thomas, 1998) states: "It is attractive to be able to engage with a new technology in easy stages, buying units of RWH storage piecemeal over several years rather than having a massive outlay in year one." He continues by saying that "splitting storage between several small tanks offers greater security against tank failure and may reduce guttering costs."

In studying the motivations of the early adopters of RWH in Utah, this research will outline the extent to which other factors, in addition to financial incentives and benefits, influenced them to adopt the practice and whether cost or political barriers played a role in their decision as well.

CHAPTER III

METHODS OF RESEARCH

In accordance with state law, the Utah Division of Water Rights (DWRi) maintains a website where individuals throughout the state can register as rainwater harvesters. In addition, the website compiles a list of those who have registered to date. The website where rainwater harvesters register, as well as the list of individuals who have previously registered, is publicly available at the following address: https://waterrights.utah.gov/forms/rainwater.asp

This research began with the list of registrants. The research mechanism that seemed to make the most sense for this study of the motivations of Utah rainwater harvesters was to simply survey the early adopters—the individuals who have registered with the DWRi. As stated in the previous chapter, there are currently just over 1000 people who have registered as rainwater harvesters with the DWRi. The first step in working with the list of registrants was to copy the list, in its entirety, from the DWRi website into Microsoft Excel so that it could be sorted and analyzed. As a matter of interest, the list of addresses was also copied into a Google Map which plotted each of the addresses for a visual representation of where the registered rainwater harvesters are located throughout the state, as shown in Figure 3.

The online form on the DWRi website that individuals fill out in order to register is fairly open with few restrictions. As a result, the information that people have provided varies somewhat in content. For example, registrants are asked for the storage size of their RWH system. Some people entered just a number, presumably the

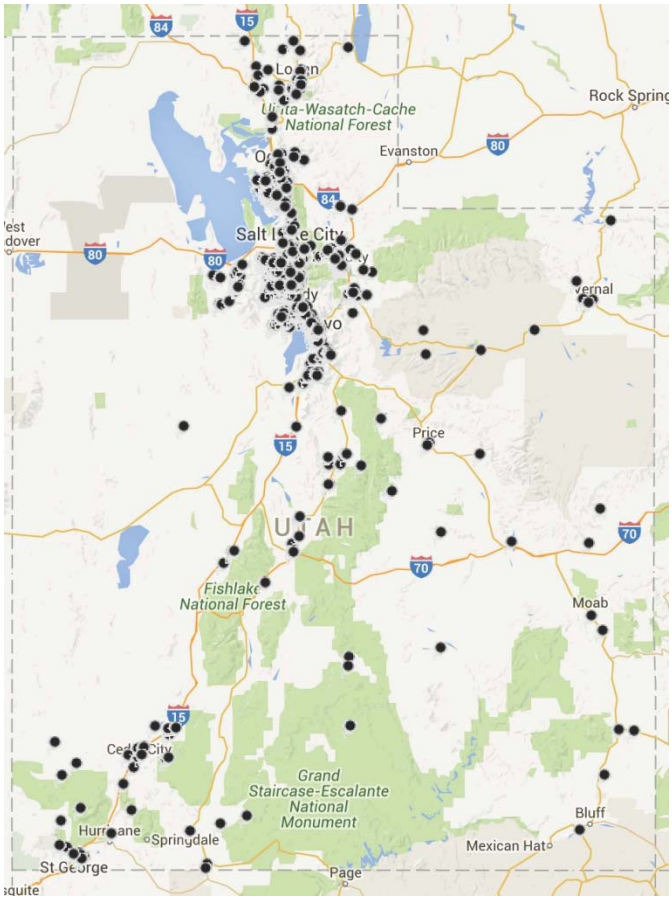


Figure 3. Rainwater harvesters in Utah. (Retrieved from Google Maps February 27, 2016.)

number of gallons their system will hold (i.e., 500, 1800, 2500) while others included "gallons" (i.e., 200 gallons). Still others reported the amount in other ways, such as "2,500 gallons on 40 arid acres" and "4- 55 gal drums" and "To be determined." In order to sort the list by storage capacity, another column was added in the Excel spreadsheet and just the number of gallons was entered for each registrant. For those who had entered just a number, the number was copied to the new column. For those who entered something other than just a number, the number that made the most sense was transferred to the new column. For example, "2,500 gallons" became "2,500" and entries such as "4-

55 gal drums" became "220" (4 x 55 = 220). Entries where there was no discernible number such as "to be determined" and "Unknown," etc., were left blank in the new column.

Another early discovery was that there is likely no confirmation page or other indicator that registration was successful when one completes and submits the form. This is indicated by the fact that several people are listed a number of times (some as many as 5) with the exact same information. This appears to be a result of the registrants submitting several times and/or completing the form more than once. The entries with duplicate information were eliminated so as to leave just one entry for each registrant. In doing this, it was discovered that a few people had registered more than once but with a different address. These entries, although for the same individuals, were kept in the list, because those individuals likely had two RWH systems (two homes or properties with a system for each one).

Once all the duplicates were removed and the extra column was added and completed for each registrant, the list was sorted by storage capacity, using the numbers in the new column. As shown in Figure 4, the majority of registrants have fairly small RWH systems (less than 250-gallon capacity) with a good number having a capacity of 2,500 gallons, the maximum capacity allowed by law. Significantly smaller numbers of registrants have systems with storage capacities between 250 gallons and 2,500 gallons.

It was assumed that the most meaningful and useful information would be gained if the survey were limited to those individuals who had made significant investments in their RWH systems in both time and money. Therefore, after sorting

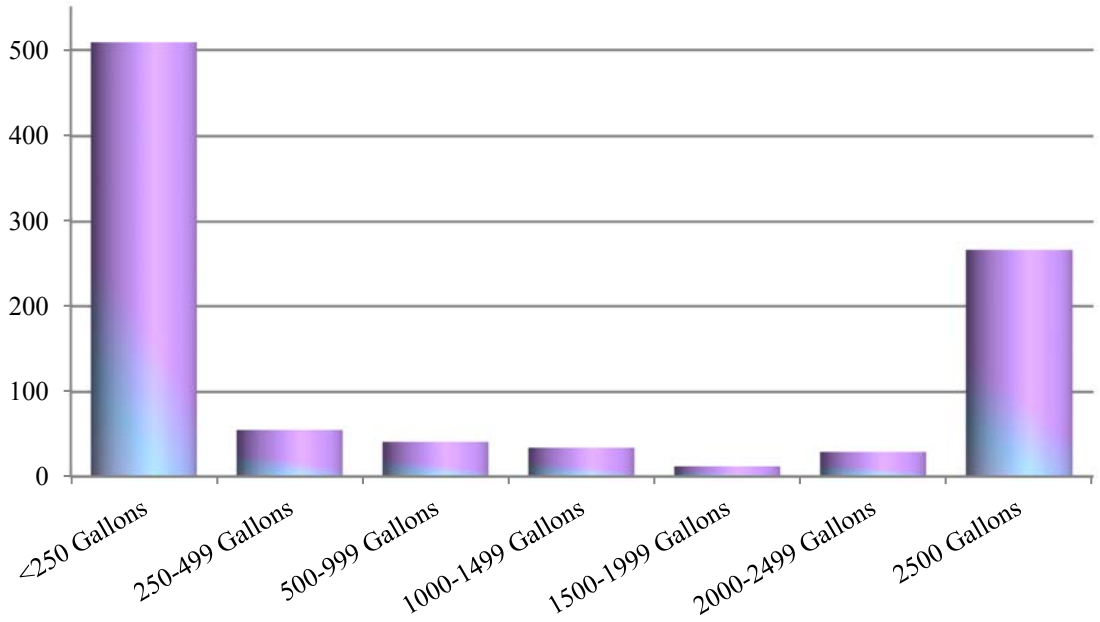


Figure 4. Number of registered rainwater harvesters in Utah according to tank size.

the list of registrants, we selected only those who had a storage capacity of 500 gallons or more, which resulted in 382 registrants.

While the DWRi webpage includes a place for registrants to enter their email address, these are not included in the compiled list of registrants that is available to the public. We therefore contacted the DWRi and informed them of our research and inquired if they would provide the email address for those individuals whom we wished to survey. They kindly agreed if we would simply provide them with a list of the registrants who we wanted email addresses for. The Excel spreadsheet with the 382 selected registrants was emailed to the DWRi and they responded with the email addresses for each of them.

The survey instrument that was used to develop the survey questions and distribute it to the rainwater harvesters was the online survey tool Qualtrics (n.d.). The

list of email addresses that had been provided by the DWRi was copied into a contact list within Qualtrics. The software identified 9 duplicate email addresses. This was most likely because of those who had registered two RWH systems but used the same email address. At this point, these duplicates were eliminated, resulting in 373 individual email addresses.

Development and Administration of the Survey

The first point of contact with the individuals on the list of registrants was an email that informed them of our research and the goals and purpose of it and asked them to participate. It thanked them in advance for completing the survey and included a link to the Qualtrics web page where the survey was found.

Once respondents clicked on the link in the email, a Letter of Information (LOI) that included more detailed information about the survey and our research appeared as the first question. They were asked to carefully read the letter before deciding to continue. If they agreed to finish the survey, Qualtrics directed them through the rest of the questions. If not, they were directed to the final page of the survey without completing any other questions. At the end of our survey period, there were seven individuals who decided not to continue with the survey after reviewing the Letter of Information.

The first couple of questions that respondents were asked after reviewing the Letter of Information were about the storage capacity and size of their RWH system and how they learned they needed to register with the DWRi. The next group of questions

inquired further into the setup, function, and use of the respondents RWH systems. This was followed by a group of questions that explored the respondent's attitudes towards water conservation in general. The final question group was composed of general demographic questions. At the very end of the survey, respondents were asked if we could contact them again in the future to ask for additional information. A space was provided for them to enter their preferred contact information. A complete list of the questions that appeared in the survey is included in Appendix B.

Per university and federal regulations and requirements, each of the survey questions, the text of the email that the registrants received, and the Letter of Information that appeared as the first question of the survey (see Appendix A) was reviewed by the Institutional Review Board (IRB) at USU and revised according to their instruction and comments (see Appendix E). This review ensured that the questions were clear and unbiased and that our research process was such that those who would respond to the survey were protected from the invasion of privacy or other harm.

Once approval had been granted by the IRB to move forward with the research, the survey was emailed to the list of 373 individuals. After one week, 68 individuals had completed the survey. At this point, a reminder email that contained the same text as the original email was sent to those who had not yet completed the survey. After the second week, an additional 40 individuals had completed it and another reminder email was sent to the remaining unfinished respondents. After another five days, 109 surveys in total had been completed resulting in a response rate of 29.2%. At this point an email was sent to those who had finished the survey thanking them for their time and participation in the

research. No further surveys were completed following this last communication with respondents.

The first review of the 109 completed surveys revealed the seven that contained no information because those respondents had decided not to participate further after reading the letter of information (Qualtrics viewed their response as a completed survey but their participation was removed from further analysis because they had not answered any of the survey questions). For this reason, the number of respondents (n) is, at most, 102 for many of the survey questions.

A number of people sent emails regarding technical problems with the survey (they couldn't access the survey; it wouldn't load, etc.) but because others were able to take it without problems, nothing was done to remedy these limited issues other than to reply to those that seemed to warrant a response. A few people sent emails with other thoughts and comments about the survey, the research project, and water conservation in general and these were also responded to as appropriate. A complete list of the emails received and how they were responded to, if such was the case, is included in Appendix A.

Documentation and Analysis of Completed Surveys

When the survey respondents submitted the survey, Qualtrics compiled the data and ran preliminary statistics on it automatically, determining what percentage of respondents answered each survey question in a certain way. Further analysis was done later, also through Qualtrics. In addition, at the conclusion of the survey period, the raw

data was downloaded into Microsoft Excel for further sorting and analysis.

Question two (Q2) asked about storage tank capacity. Several people entered "max" instead of a number. As the maximum tank size allowed by state law is 2500 gallons, these responses were changed to "2500." Others entered "?" and one entered "duno." These were deleted and not included in the further analysis of the responses for that question. A few respondents included some nonnumerical characters in their answers (i.e., "400p," "500+," and "&It;500"). The nonnumerical characters were removed, leaving just the number. The list of storage capacities was then sorted and graphed. Question two was the only question on the survey that required the respondents to input a value; all the other questions were multiple choice.

Several of the other questions (numbers 3, 6, 7, 9, 10, 13, & 14) did include an "other" option and provided the ability to enter something different than one of the predetermined values. The text that was entered for these "other" type questions is included in Appendix C exactly how the respondents entered them into the survey.

CHAPTER IV

RESULTS AND CONCLUSIONS

Basic Demographics of Respondents

Q16 - Gender of Respondents

The vast majority of survey respondents were male (84.31%; see Figure 5). This may be a result of men being more willing and able to engage in RWH than women but it could also simply be a result of the male in a family setting being the one to have received the email with the survey.

Q17 - Age of Respondents

The age groups of respondents ranged from 25-34 to 85 or older with the most sizeable age group being 55-64 years old (see Figure 6). This could indicate that those

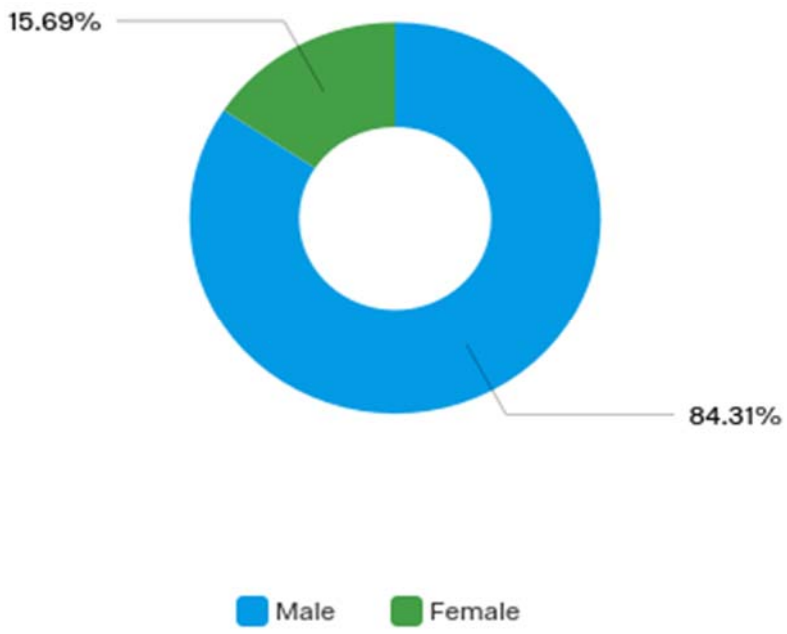


Figure 5. Gender distribution of respondents (Q16, *n* = 102).

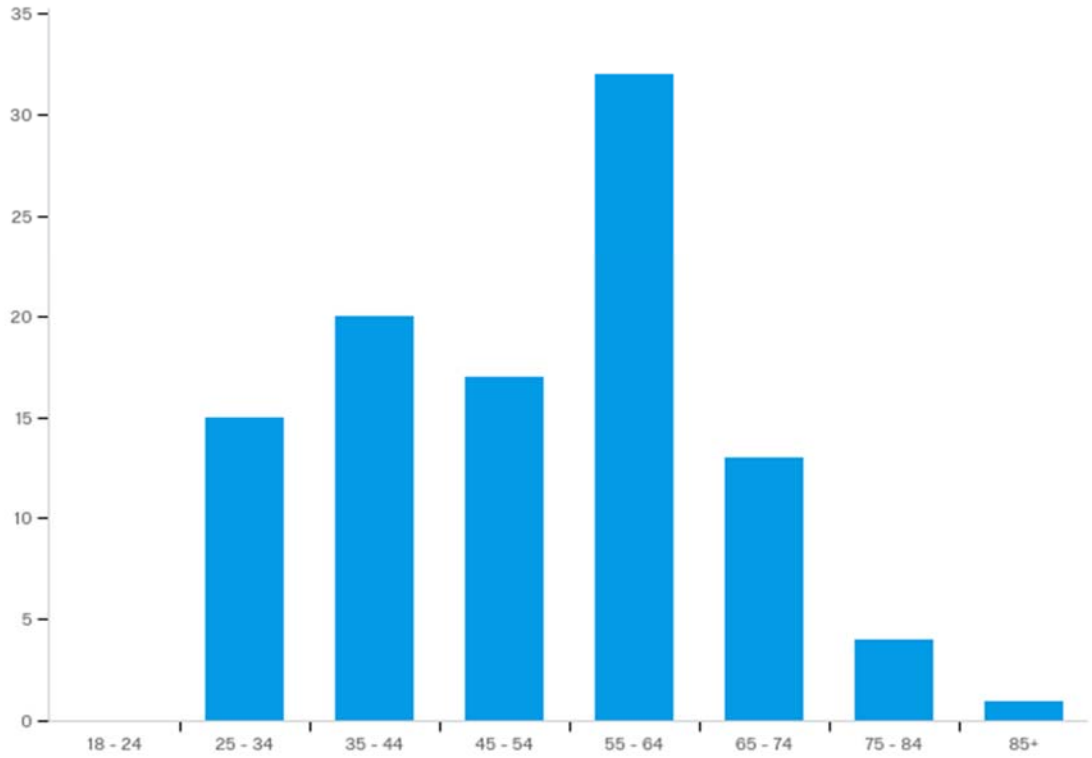


Figure 6. Age ranges of respondents (Q17, *n* = 102).

who are middle-aged might be more willing and able to afford, install, and maintain a RWH system. However, the fact that the data leans towards the younger to middle-aged groups might also be a result of the individuals in those age groups being more apt to taking an online survey.

Q18 – Education

Question 18 asked about the level of education that respondents had achieved. The results, as shown in Figure 7, indicate that those who practice RWH are generally well educated. Over 70% of respondents had a 4-year degree or higher and 96% had at least some education beyond high school.

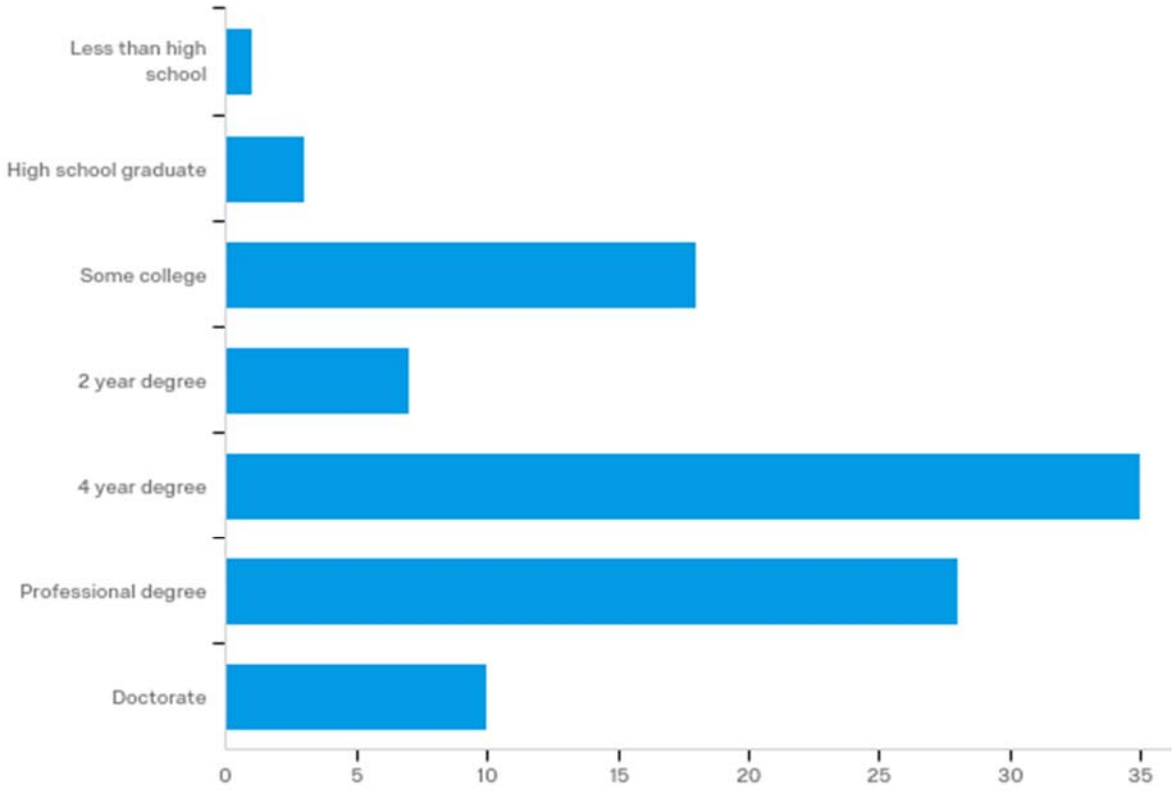


Figure 7. Education levels of respondents (Q18, *n* = 102).

Q19 – Employment

With similar results to education level, almost 70% of respondents reported being employed full time. Nearly 17% (16.67%) reported being retired with very few being employed part time, unemployed-looking for work, unemployed-not looking for work, students, and disabled (see Figure 8).

Q20 – Income

The results for income levels are a bit more evenly distributed than some of the data sets on other topics, but the data is still weighted towards the higher income levels (see Figure 9). The highest percentage of respondents made between $60,000 and

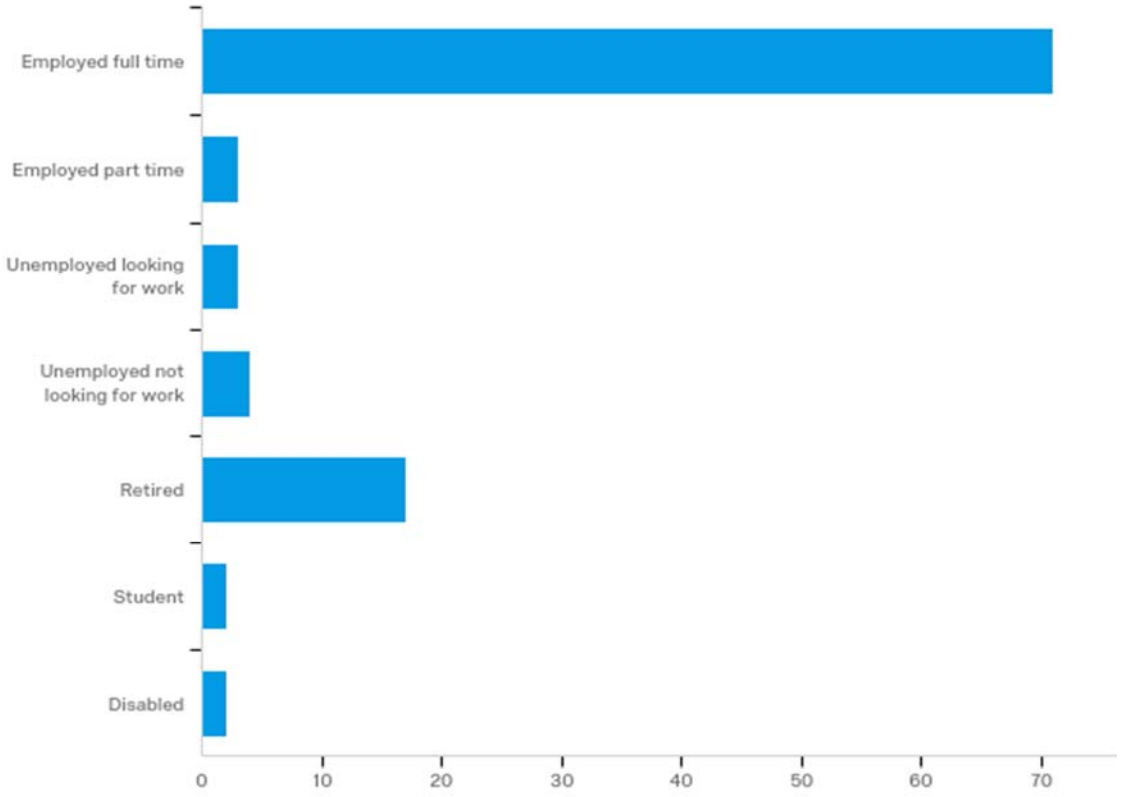


Figure 8. Respondents' employment statuses (Q19, *n* = 102).

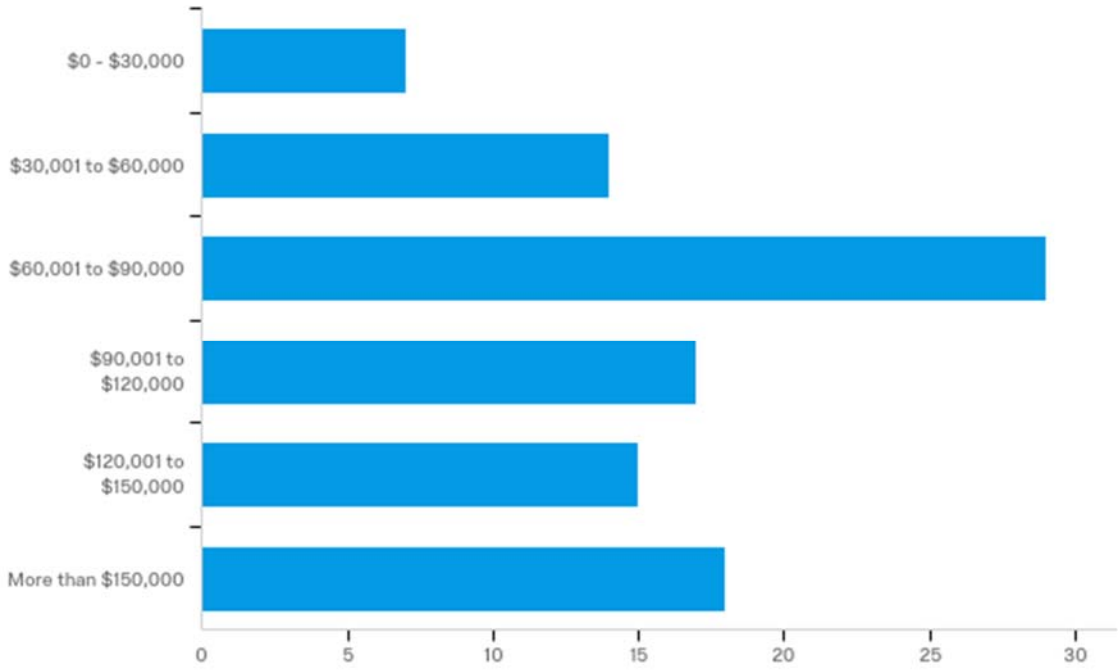


Figure 9. Respondents' income levels (Q20, *n* = 100).

$90,000 (29%) and half of respondents earned more than $90,000 in 2016. The median household income for Utah in 2015 was just over $60,000 (U.S. Census Bureau, n.d.). This indicates that those with higher incomes are more likely to harvest rainwater. It is interesting to note along with this data that the range that the majority of respondents paid for their RWH system (discussed below) is quite a bit lower than expected. So, although people with higher incomes are more likely to harvest rainwater, they still don't invest all that much in their RWH system.

Q21 – Environmental Context

Figure 10 shows that close to half (43.56%) of the respondents classified the environmental context of their home and neighborhood as suburban. The results for "somewhat urban" and "somewhat rural" were almost identical at 7.92% and 8.91% respectively. Responses for "urban" and "rural" varied slightly more at 23.76% and 15.84%, respectively. For comparison, only 10.6% of the entire Utah population lives in a

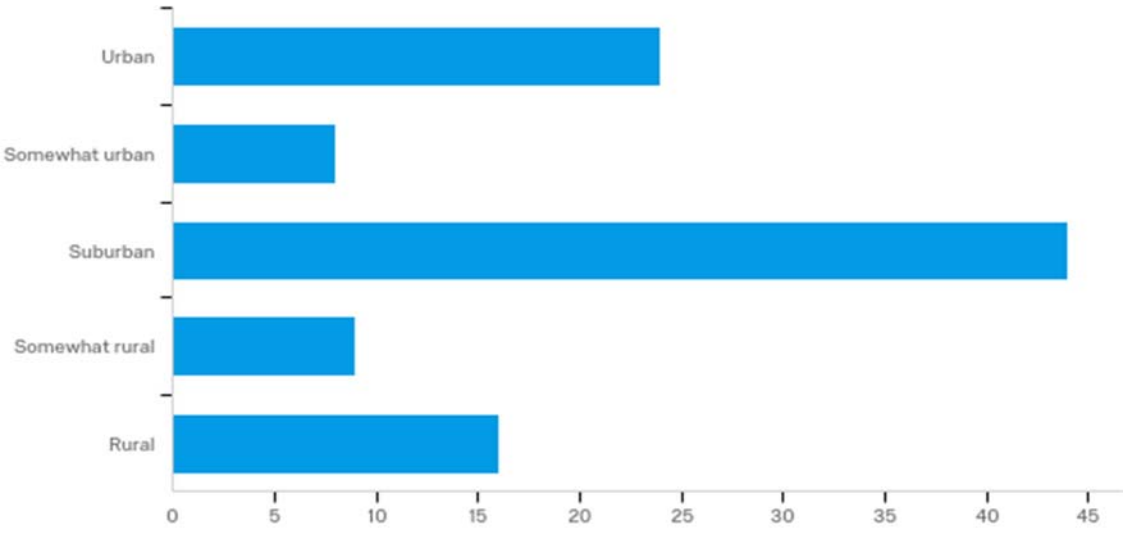


Figure 10. Environmental context of respondents' homes and neighborhoods (Q21, $n = 101$).

rural area with the remainder (89.3%) living in urban areas (Parker, 2018). This is the most evenly distributed data in the survey results which appears to be quite different from the rest of the population.

Q22 – Political Views

Utah is a predominantly conservative state in general with 54% of the population identifying as conservative while 30% leans liberal (Pew Research Center, 2015). The survey results indicate that rainwater harvesters throughout the state also hold true with this data and lean towards the conservative (see Figure 11). Nearly 20% of respondents claimed to be more on the liberal side (19.8%, very liberal and liberal combined). Those with moderate political views—the category with the highest percentage—holds 32.67% of respondents.

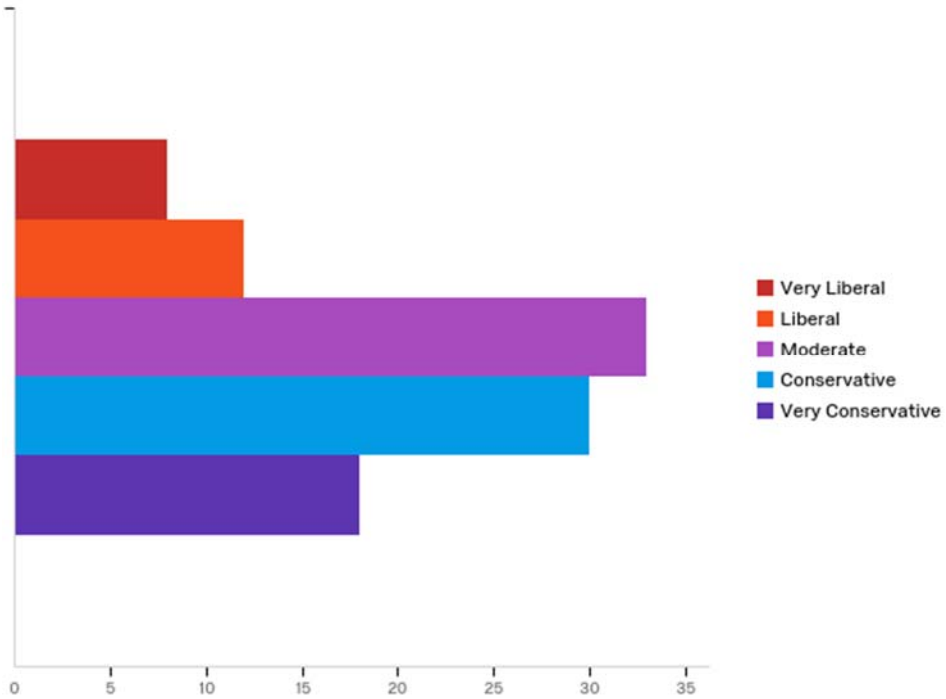


Figure 11. Respondents' political views (Q22, *n* = 101).

Summary of Demographics

A review of the general demographics of the survey respondents indicates that the typical rainwater harvester in Utah is a well-educated, middle-aged male who holds a full-time job and earns more than the state median income level, lives in what he considers to be a suburban area, and has moderate to conservative political views. Comparing these results to data for the general population of Utah can be quite instructive. The differences as well as the similarities between the two could be used to create a strategy for encouraging others in the general population of Utah to harvest rainwater. Once we understand what enables and motivates the current harvesters to practice RWH we can use demographic data—as well as other data that will be discussed below—to begin to formulate a plan for how to educate and encourage other Utahans to adopt the practice.

Analysis of Rainwater Harvesting and Conservation Questions

Rainwater Harvesting System Specifications

> Q2 - What is the capacity of your rainwater harvest and storage system in gallons? (When you registered with the Utah Division of Water Rights (DWRi) as a rainwater harvester, how many gallons did you indicate you would be harvesting?)

The survey had been sent to only those individuals who had registered with the DWRi as harvesting over 500 gallons. In theory, the amount they entered when registering with the DWRi and the amount they entered for question number two, which asked for their RWH system storage capacity, should have been the same. Oddly, there is some discrepancy between the two numbers; 12.75% of respondents entered values less

than 500 gallons. It is indeterminate whether the survey or the DWRi registration list would be more correct. Over a quarter (28.43%) of the respondents, though, claimed to be harvesting 2,500 gallons, the maximum legal amount. Well over half of respondents (59.18%) are harvesting 1000 gallons or more (see Figure 12). The goal of the survey was to get responses from individuals with larger RWH systems that had been required to make significant investments of both time and money into their systems. Based on these results, it appears that the survey was successful in this objective.

Q3 - Where & how did you learn that you needed to register your rainwater harvesting activity with the Division of Water Rights (DWRi)?

Just over 16% of respondents reported that they learned about registering as a rainwater harvester with the DWRi when Utah Senate Bill 32 was passed. The same number of respondents claimed learning about it from a friend or neighbor. A quarter of

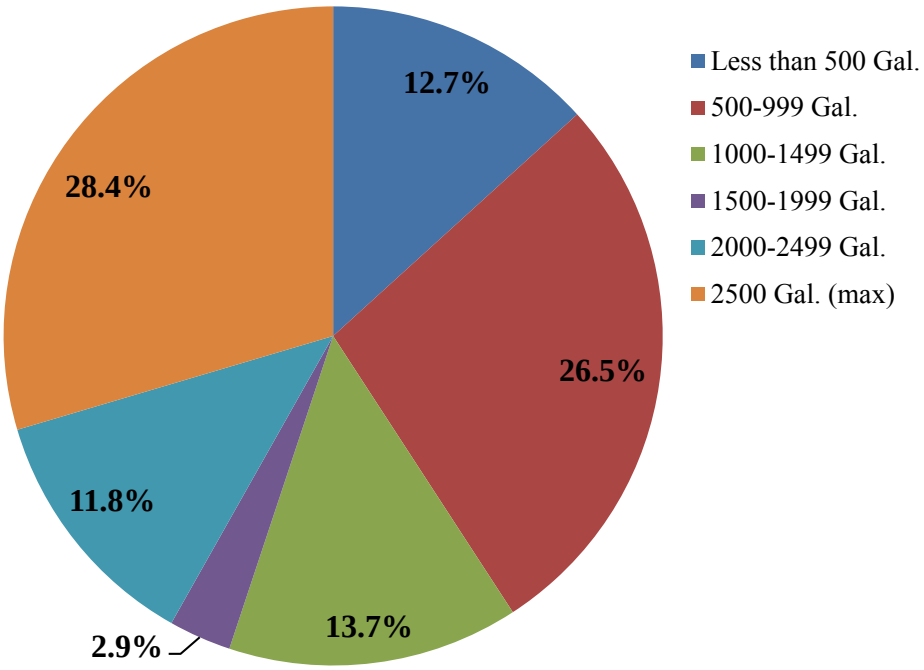


Figure 12. Rainwater harvesting system storage capacity (Q2, *n* = 102).

respondents said they learned of the requirement to register while visiting the DWRi website. Interestingly, 35.58% marked “other” and over half of these wrote in something related to either another website or online research in general. Also of note, less than 2% reported that they learned of the need to register when they purchased their rainwater storage tank (see Figure 13). This could be a possible opportunity for outreach for the DWRi. If the DWRi were to encourage businesses that sell RWH equipment and supplies to tell their patrons about the need to register, it might increase the numbers of people that actually do register, which could result in a more accurate view of how many people throughout the state are currently harvesting rainwater.

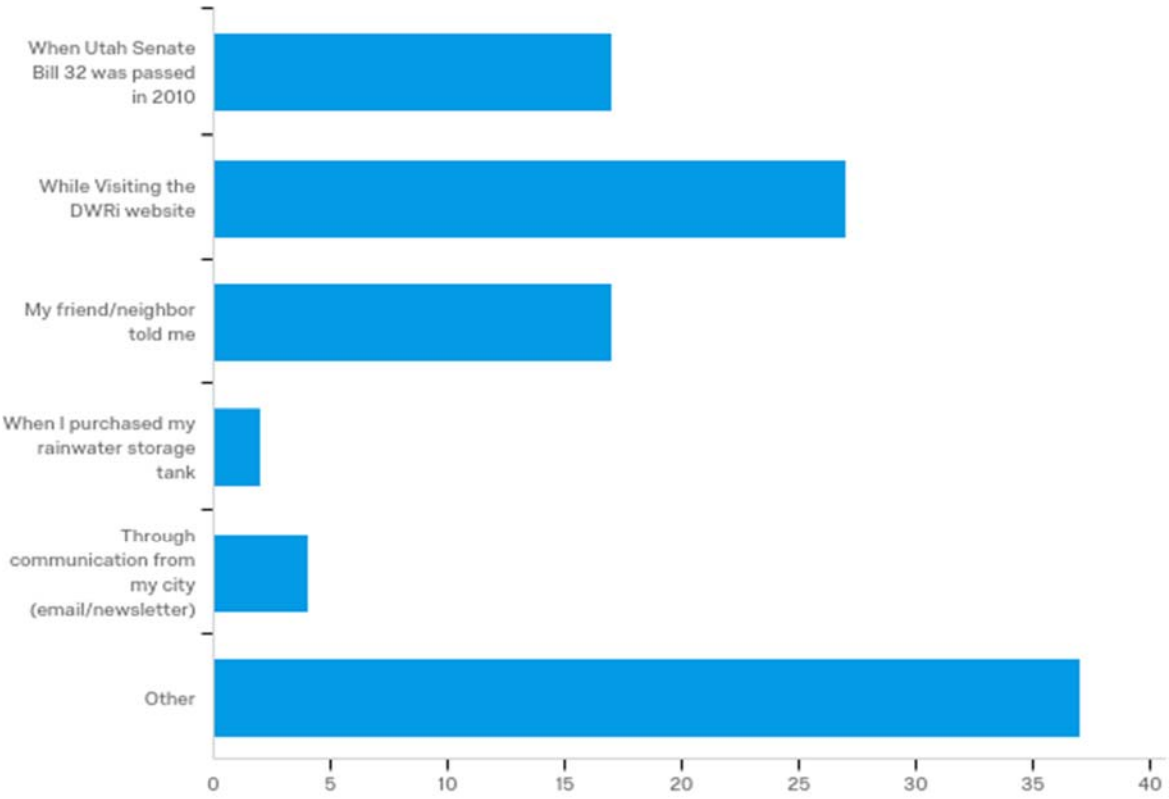


Figure 13. Knowledge of DWRi registration requirement (Q3, *n* = 104).

Q4 – Are your main reasons for harvesting rainwater economically/financially motivated or environmentally motivated?

Figure 14 shows that over half of the respondents claimed that their RWH activity was both economically/financially as well as environmentally motivated. The rest of the data leaned somewhat towards environmentally motivated. It is interesting that Krishna (2005) and Thomas (1998) stated that reducing costs is an important factor to consider when encouraging others to practice RWH, but these results may indicate otherwise. According to the results here, saving money does not seem to be as big of a motivator as had been assumed. However, it does indicate that most rainwater harvesters in Utah are concerned for the environment. This seems to beg the question that if RWH provided only a financial benefit, and had no impact on the environment, would Utah rainwater

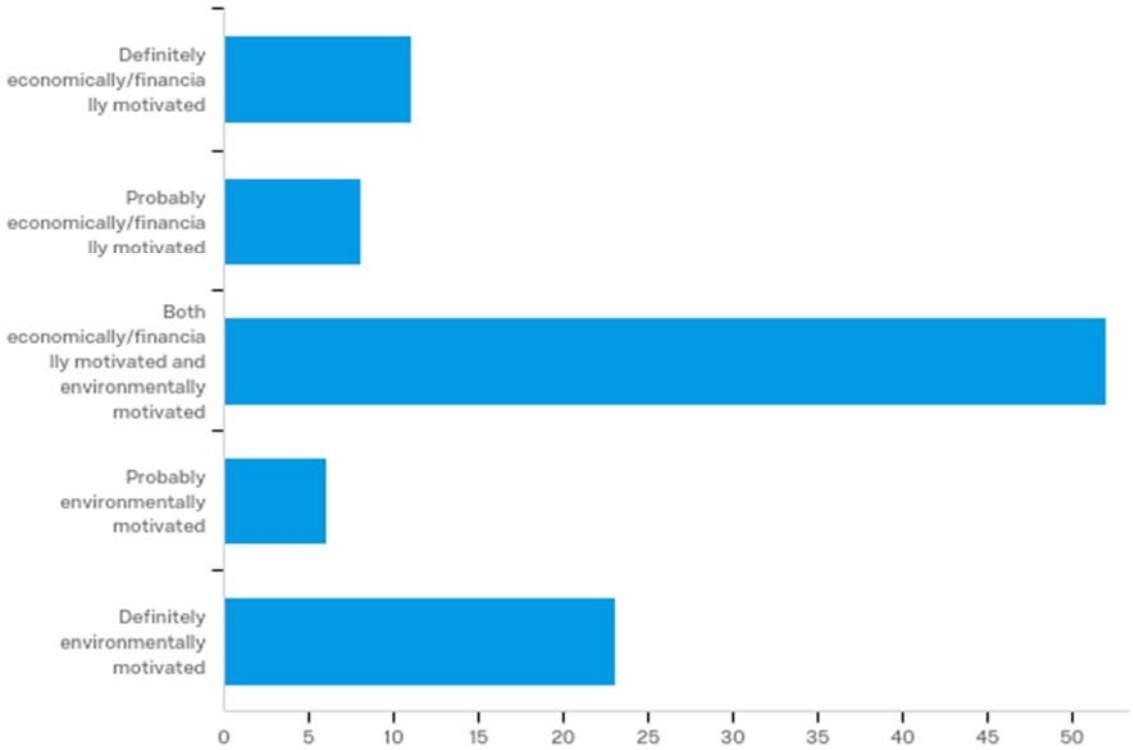


Figure 14. Economic/financial vs. environmental motivation (Q4, *n* = 101).

harvesters still choose to engage in it? On the other hand, if RWH only provided an environmental benefit, and there was no potential to save money by practicing it, would they still choose to harvest? These results suggest that RWH needs to have some level of benefit in both areas to be appealing to the average harvester.

> Q5 – Please indicate the range of what you paid for your rainwater harvesting system (please include the cost of equipment and supplies as well as installation, if applicable).

The range that respondents paid for their RWH system that took the overwhelming majority (60.82%) was $0-$500 (see Figure 15). This seems to be a rather low range when comparing this data to the average amounts that the literature claimed an average RWH system would cost—as much as $15,000 (Courtney, 2008). If this is

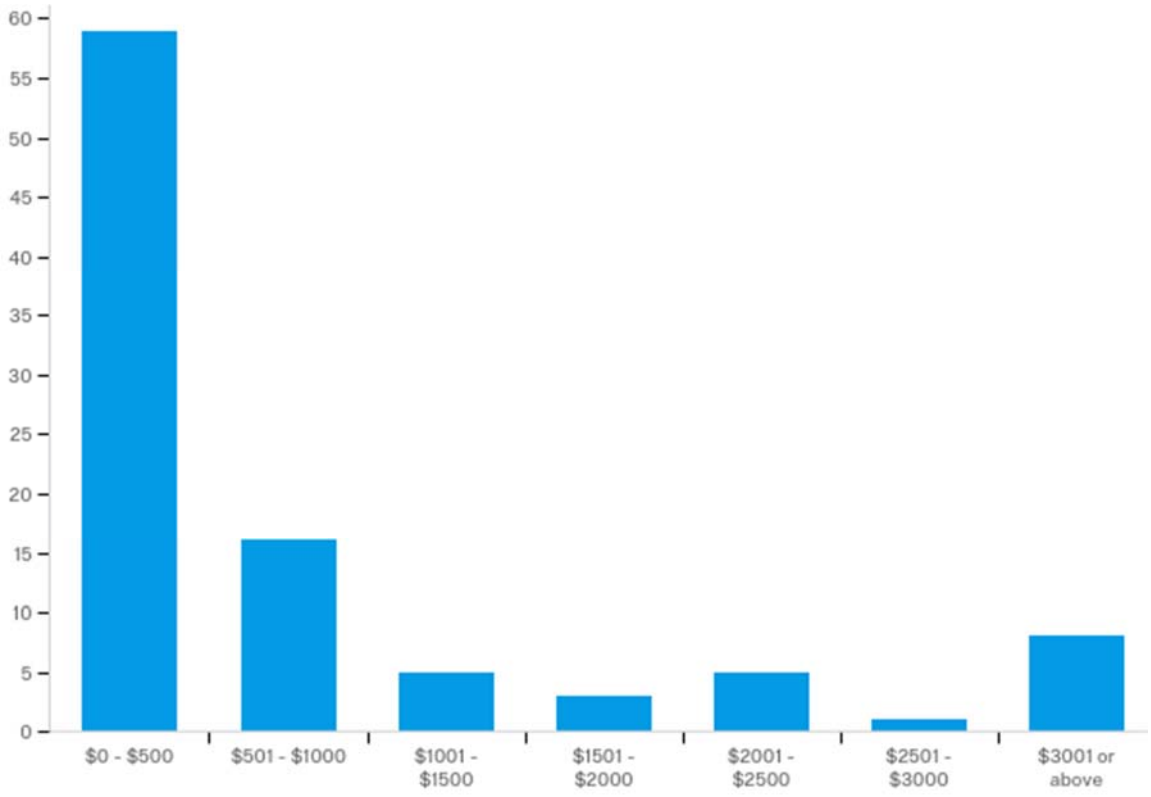


Figure 15. Expenses incurred for rainwater harvesting system (Q5, *n* = 97).

accurate, the low investment requirement doesn't seem to be as big of a barrier to RWH as had been assumed. If this is the case, trying to encourage others to harvest rainwater by lowering the cost may not be the best strategy, at least in Utah. It is possible that people just don't know how inexpensive RWH can be. An informational campaign on a statewide scale to educate the general public on basic principles of RWH and its relatively low cost could be more influential in encouraging Utahans to harvest rainwater than simply lowering the cost.

The maximum RWH storage capacity is limited by state law to 2,500 gallons. It is possible that the cost of a RWH system is not currently a significant issue in Utah because storage tanks of 2,500 gallons or less are more affordable than larger tanks. If the limits on capacity and tank configuration were removed by the state legislature, figuring out ways to reduce the costs—especially of larger RWH systems—might be more important.

Summary of Rainwater Harvesting System Specifications Questions

The majority of the respondents have fairly sizeable storage tanks, with regards to the state limit on capacity, but most also spent relatively little on their RWH system. In light of the fact that most respondents learned about the need to register with the DWRi from online sources, a useful addition to the DWRi website and other sites concerned with RWH in Utah would be information on how affordable large tanks can be. Although most Utah rainwater harvesters claim they are motivated by concern for the environment, framing RWH in terms of financial savings will likely continue to be a useful strategy.

Storage Method, Use of Rainwater, and Benefits Gained

Q6 – What method do you use for storing the rainwater you have harvested?

As shown in Figure 16, nearly half (42.16%) of the respondents reported that they store their rainwater in an above-ground closed plastic tank. More than 20% have an underground plastic storage tank and another 21.57% marked "other" and then provided a written answer (see Appendix C). Many of these stated that they had not yet installed their RWH system and were not sure what type of material it would be if and when they do have it installed. Some said they had more than one type of storage.

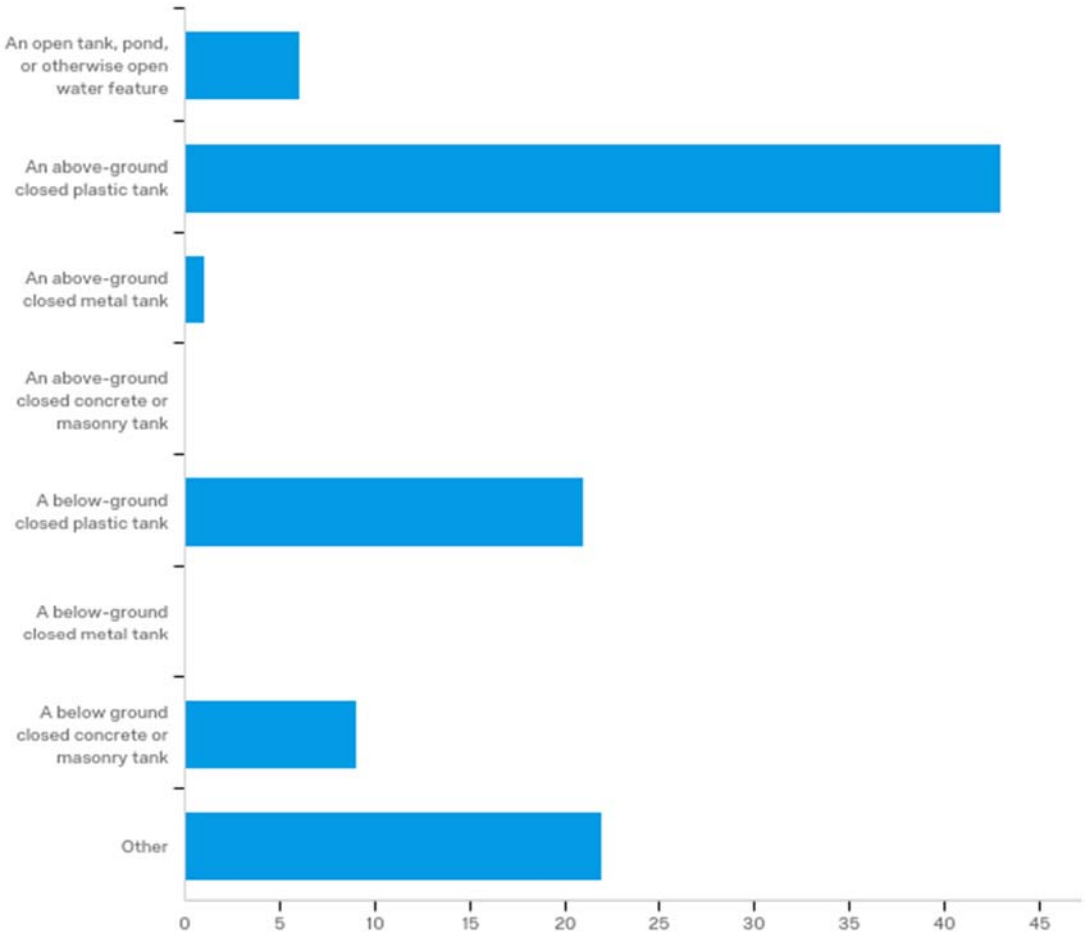


Figure 16. Method/material of storage tank (Q6, *n* = 102).

Q7 – How do you use the water that collects in your rainwater harvesting system? Please select all that apply.

Seventy-three respondents claimed that they use their harvested rainwater "To water vegetable gardens." Fifty-eight said they use it "To water trees & shrubs," and 42 use it "For an emergency supply" while 33 use it "To water turf-grass." Twenty-three people stated "other." Several of these could have been included in the other categories because their written responses stated things such as "to water horses" (which could have fit with "to support domestic animals") and "to water indoor plants year-round" (which could have fit with "to water vegetable gardens" or "to water trees & shrubs) and "landscape water feature" (which could be classified as a decorative amenity). A few people claimed to be using their harvested rainwater for culinary purposes (see Figure 17).

Q8 - On a scale of 1 to 10, how beneficial do you feel your rainwater harvesting system is for the purposes you listed above?

The average of all responses to this question is 7.63 (see Figure 18). Therefore, most of the respondents feel that the rainwater they collect is rather beneficial for the purposes they use it for.

In sum, most respondents are storing their harvested rainwater in an above-ground plastic tank which is likely the most accessible and cheapest option. Understandably, most are using their harvested rainwater in the landscape, which removes most concerns for water quality issues and the majority of respondents are satisfied with the benefits they gain from their harvested rainwater.

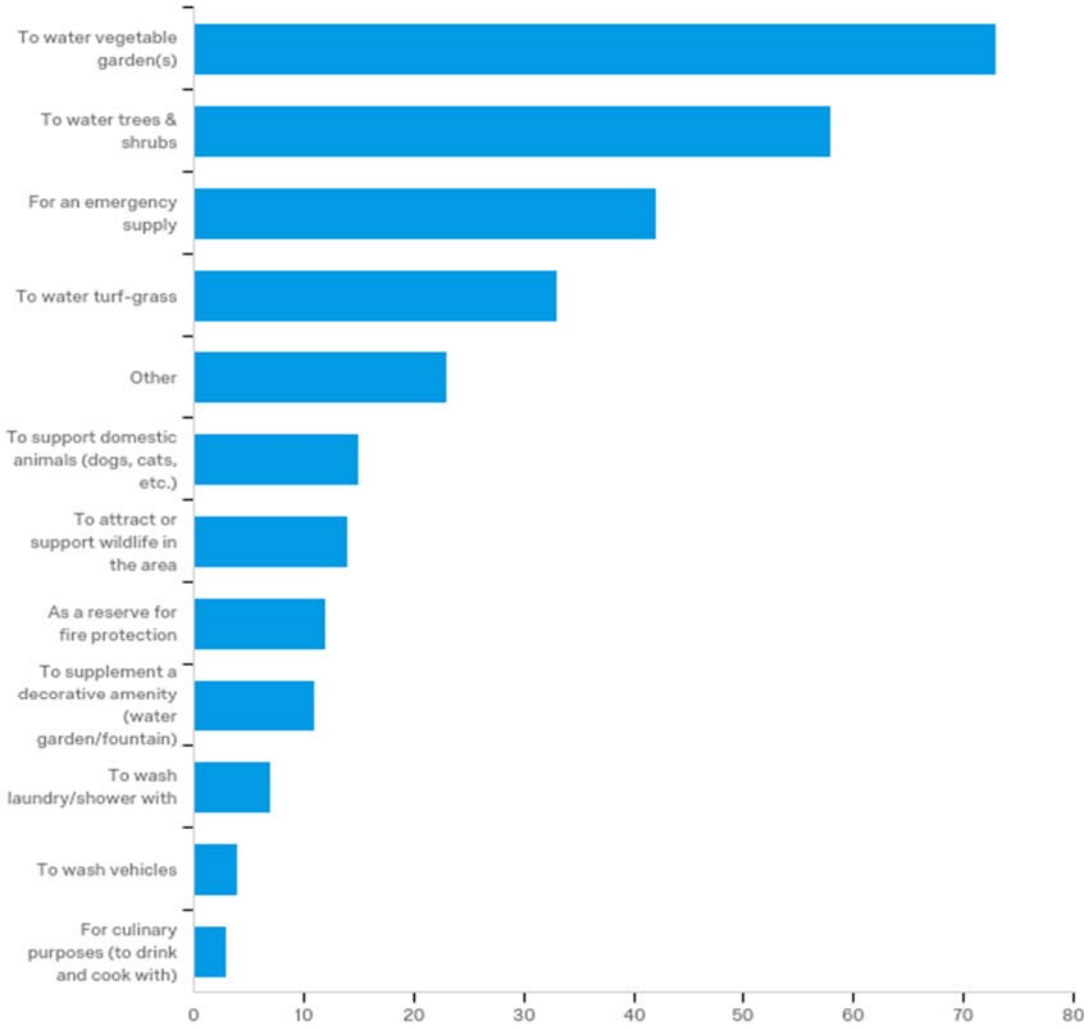


Figure 17. Use of harvested rainwater (Q7, *n* = 101).

Installation and Maintenance of Rainwater Harvesting System

Q9 – Who installed your RWH system?
Q10 – Who performs the maintenance on your RWH system?

As shown in Figure 19, almost three quarters of respondents (73%) reported having installed their own RWH system. The majority of those that reported "other" have actually not installed a RWH system yet. Similar to system installation, 88.78% of respondents perform the maintenance on their own system (see Figure 20). Again, the

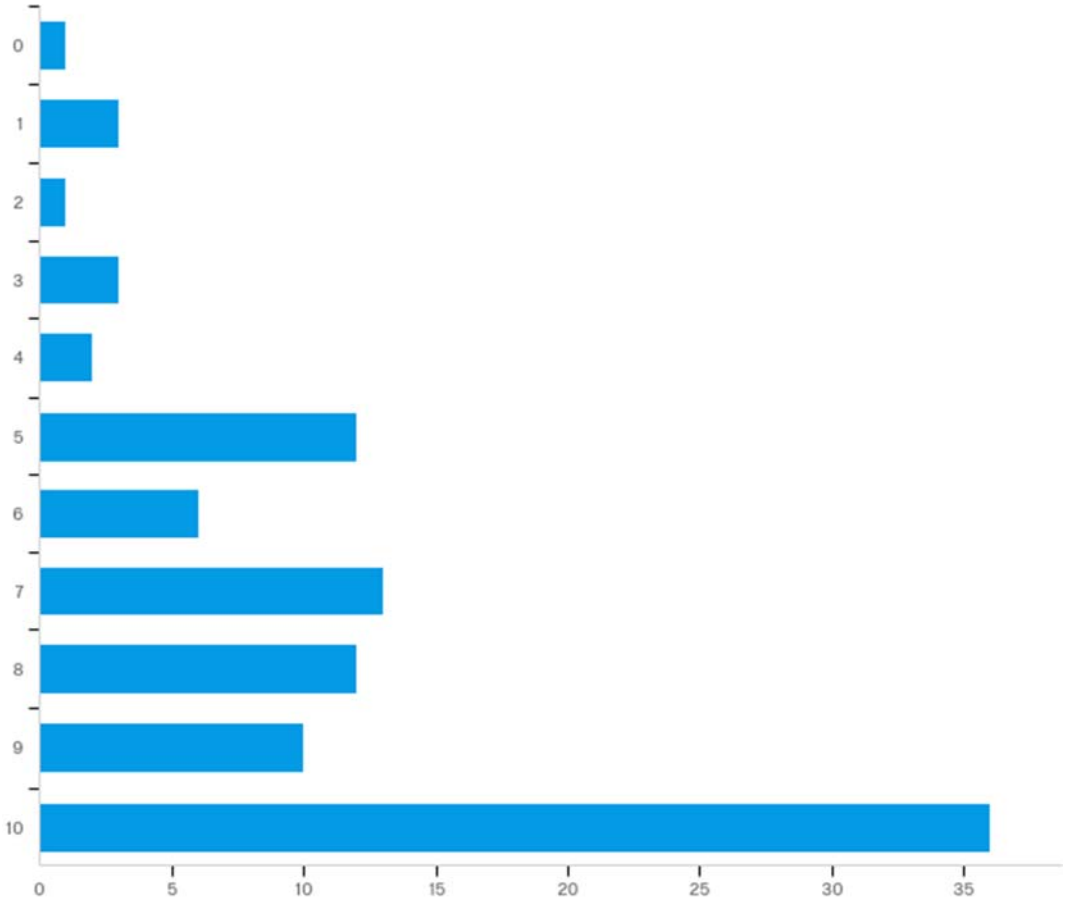


Figure 18. Choice count distribution of benefits gained from rainwater harvesting system (Q8, *n* = 99).

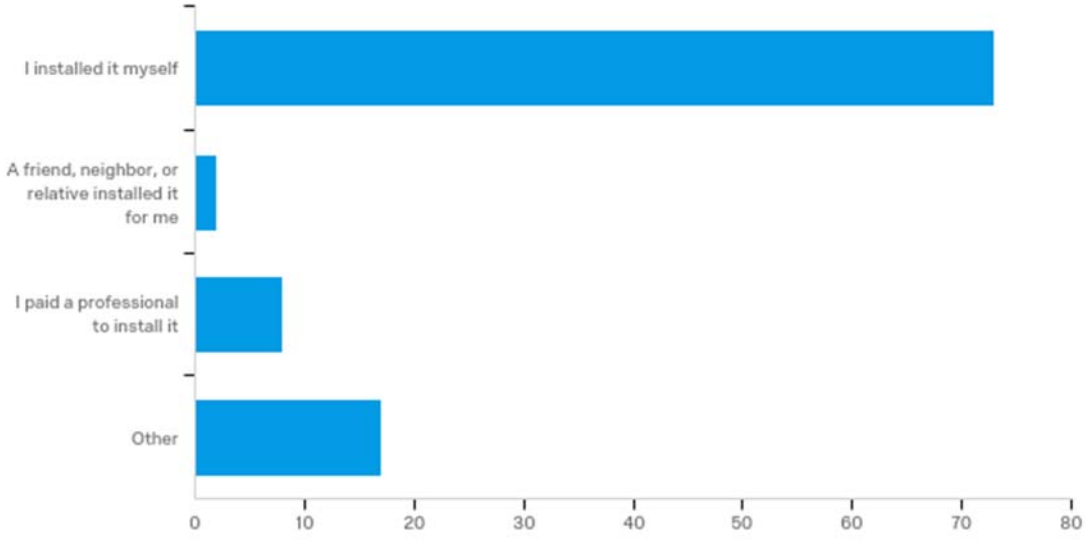


Figure 19. Installation of rainwater harvesting system (Q9, *n* = 100).

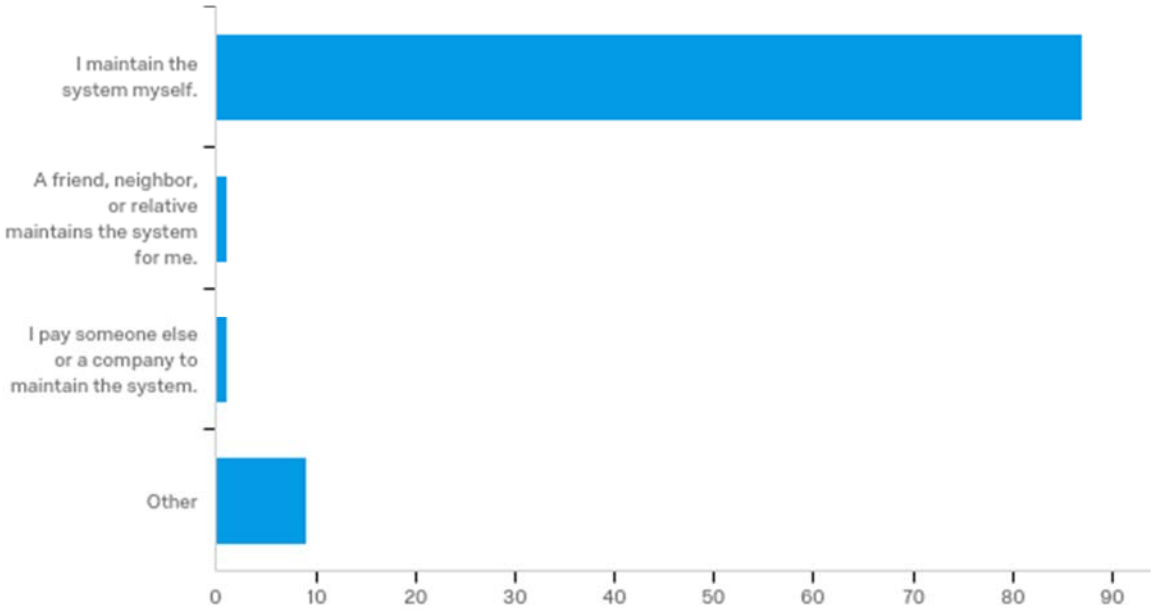


Figure 20. Maintenance of rainwater harvesting system (Q10, *n* = 98).

majority of those who responded with "other" have not yet installed a RWH system and therefore have no maintenance requirements. The high numbers of those who install and maintain their own RWH systems could be one result of the legal limits on storage capacity. Installing and maintaining a small RWH system does not appear to be overly intimidating to the average harvester. However, professionals who are experienced in RWH would likely have more equipment and resources for dealing with larger systems than the typical homeowner does. If Utah residents were not limited by the law in the size of their RWH system and it were legal to have larger systems, it is possible that more people would choose the route of professional installation.

Q11 – Would you install your rainwater harvesting system again if you had that choice?

The vast majority of the respondents (91.84%) seem to be happy with their choice to begin harvesting rainwater and said they would make the choice to install a RWH

system again if they had that choice. Only 3.06% indicated that they would not install their RWH system again (see Figure 21). It would be interesting to know why these individuals feel the way they do. This could be a possible topic of further inquiry. However, it is encouraging that most people who have begun harvesting rainwater are pleased with their decision.

These results indicate that RWH in Utah is largely a do-it-yourself kind of endeavor. Again, if the limits on storage capacity and tank configuration were removed, the data would likely have reflected a larger percentage of professional installation and maintenance.

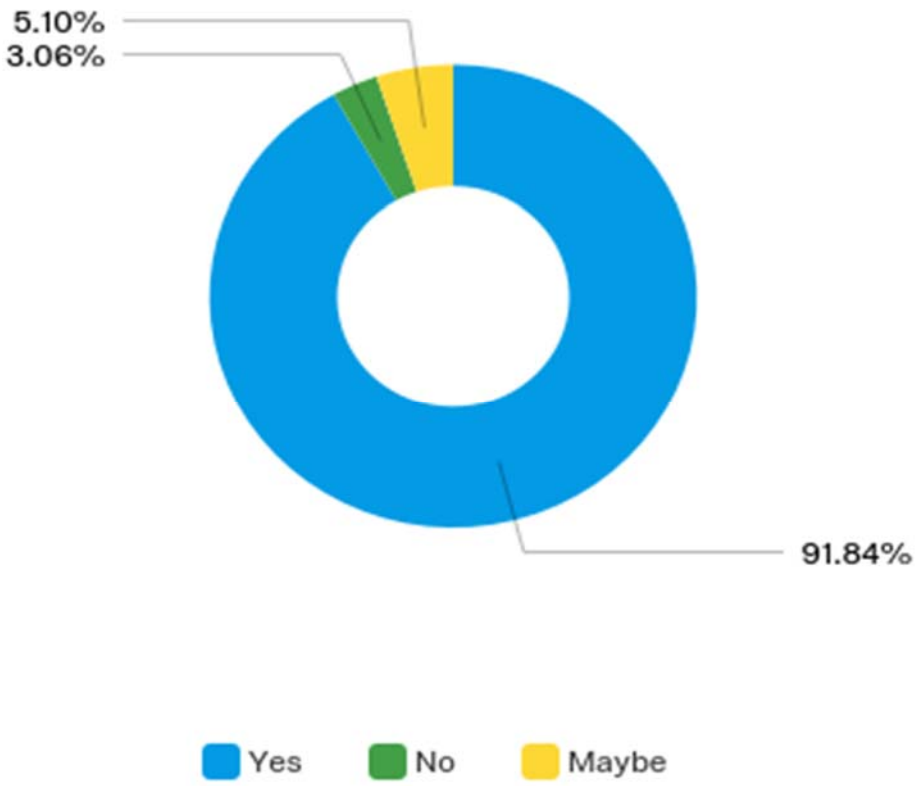


Figure 21. Would Utah rainwater harvesters choose rainwater harvesting again? (Q11, *n* = 98).

Environmental Attitudes

Q12 –How important is conserving water in general to you personally?

The results to this question show a positive correlation with the data from Q4 and indicate that the majority of harvesters are practicing RWH out of some level of environmental concern, $r(97) = 0.38$, $p < 0.001$ (responses with no data for one or the other of the questions were removed prior to this analysis). Over 75% of respondents to Q12 reported that conserving water in general was either very important or extremely important to them (see Figure 22). This indicates that they are aware of the water scarcity that exists in Utah and they understand how detrimental water shortages can be. Those who reported that water conservation is only moderately important, slightly important, or even not at all important to them personally might conserve water if it is convenient or if it brings them some other benefit, but they will likely not conserve water

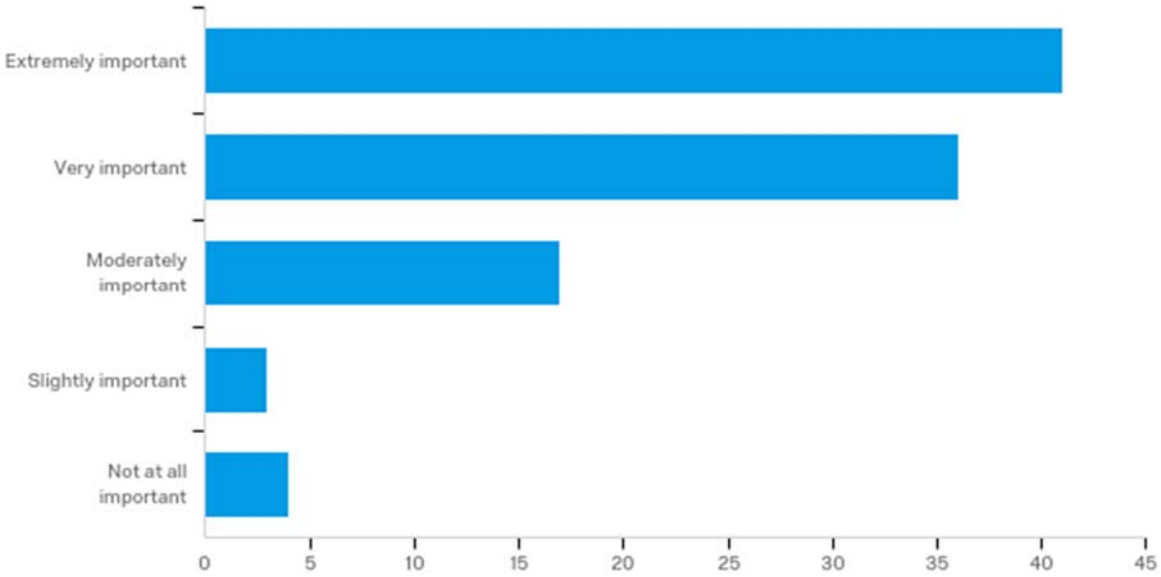


Figure 22. Attitudes towards conserving water in general (Q12, $n = 101$).

simply because they feel like it is the right thing to do. However, this might indicate a lack of education and understanding of the critical state of water scarcity in Utah, and may not just be an attitude of not caring.

> Q13 - Please rank the following items in order of what you feel could be done in your household to have the greatest impact in conserving water.

This question was placed in the survey as a way of determining where RWH fit among other water conservation techniques in the minds of the respondents. Each of the respondents ranked the different conservation techniques according to the impact they felt each one would have in conserving water. With eight options included on the survey the respondents ranked them from one (1; most influential) to eight (8; least influential). Qualtrics then averaged the rankings for each technique. This resulted in a cumulative rank for each one. By using this analysis method, the technique with the lowest number is viewed as highly influential by the majority of the respondents. Conversely, those with higher numbers are viewed as less influential.

According to the cumulative responses (see Figure 23), the most influential conservation technique is “Adjusting landscaping sprinklers and setting sprinkler timers correctly” (2.83). This is closely followed by “Replacing lawn areas with shrubs and perennial plants” (3.23) and then “Harvesting rainwater” (3.37). This is hopeful evidence to show that at least those surveyed know that we use a lot more water in the landscape than we do indoors and that the biggest impacts in conservation are also in the landscape. “Shorter shower times,” “Increasing laundry & dishwasher load sizes,” “Installing dual-flush toilets,” “Eating less meat” and “other” were ranked as the least influential conservation techniques.

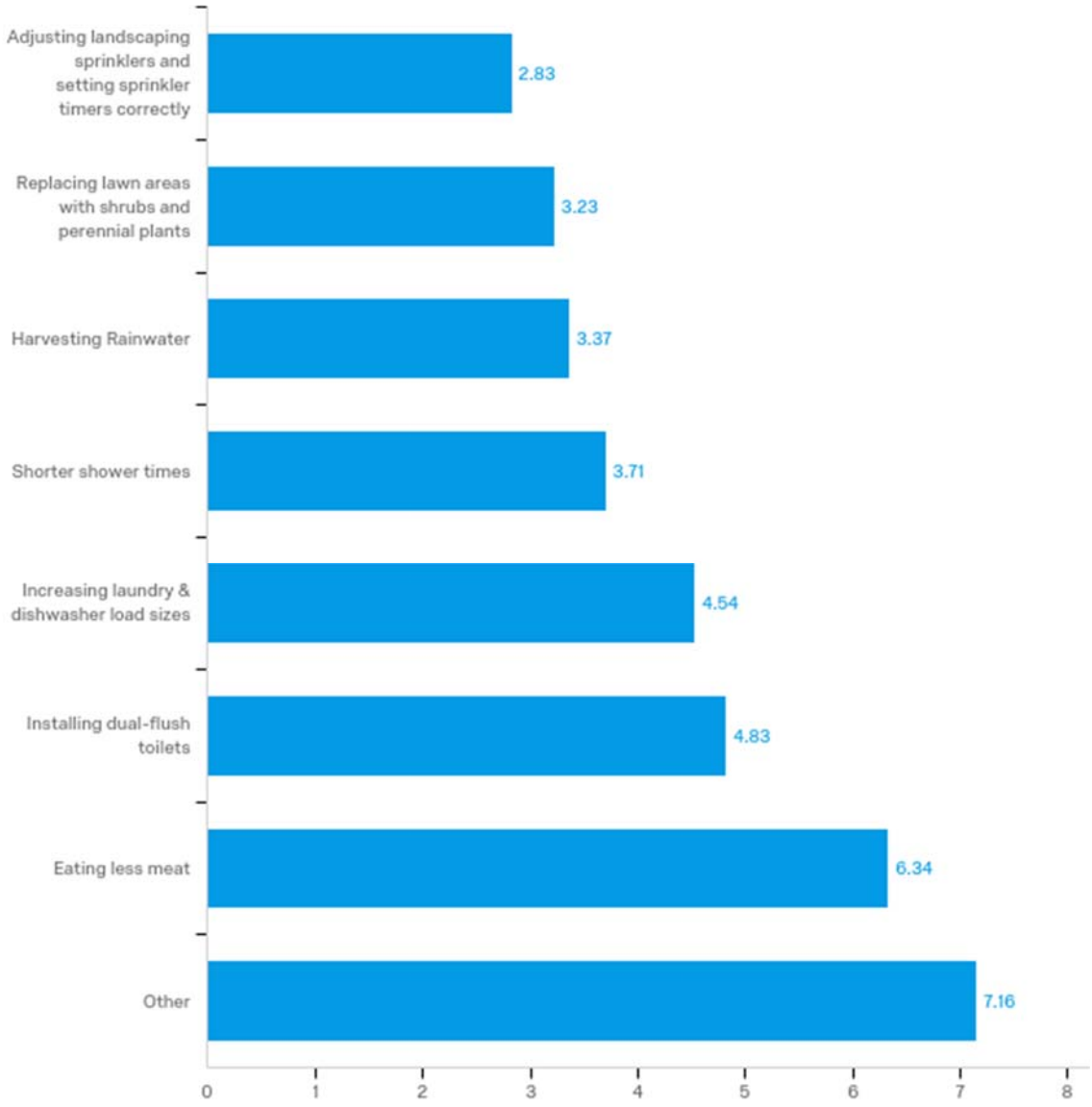


Figure 23. Rankings of activities that impact water conservation (Q13, $n = 95$).

This survey question assumes that there is always something that one can do to improve in conserving water and attempted to determine the point that the respondents were in their conservation efforts. If respondents had already done as much as they felt they could do in the landscape to conserve water it would make sense if they said the next thing they could do that would have the greatest impact was to decrease shower times, or

maybe one of the other options. However, since the three options that were ranked highest are concerned with the landscape, even those who are harvesting rainwater may feel they could still do more to conserve water in the landscape.

A number of respondents felt that "Eating less meat" was an unusual choice to include with the rest of the list as evidenced by a few of the comments in the "other" category such as "Everything except eating less meat" and "Really? Less meat?!" However, according to *Water Consciousness* (Lohan, 2008), it takes 600 gallons of water to grow the amount of corn needed to produce one third of a pound of beef for a hamburger. With this in mind, eating less meat might actually do some good in conserving water.

The written responses in the "other" category ranged from things that would actually not be very beneficial in conserving water to things that are truly meaningful and could be examined further. One individual reported "I have a small family, but the water company charges me a minimum amount that is greater than my actual use. I have absolutely no incentive to conserve water." For at least this individual, and presumably others throughout the state, there is no incentive—whether penalty or reward—for putting forth effort, or not, to conserve water. In the future, with projections of continued water scarcity and further population increase, water companies and cities will likely need to find instances and situations similar to this and develop ways to encourage all citizens to be conservation-minded.

Another respondent wrote, "Cities allowing desert landscape," which points to the fact that many cities have codes and restrictions against some types of landscape styles

which might be better at conserving water than what they do allow and promote. Such codes and ordinances need to be reviewed and modified so that when individuals would like to take certain actions to conserve water, they are legally allowed to do so. A few respondents mentioned being able to use grey water for irrigation—another topic that could use further study and effort to make it more affordable, accessible, and legal throughout Utah.

Q14 - What is the largest factor(s) that influenced you to begin harvesting rainwater? (Please select all that apply)

Nearly half (46.5%) of respondents claimed that "To have an emergency supply of water" was one of the largest factors that influenced them to begin harvesting rainwater (see Figure 24). This is not surprising in light of the fact that over 60% of the

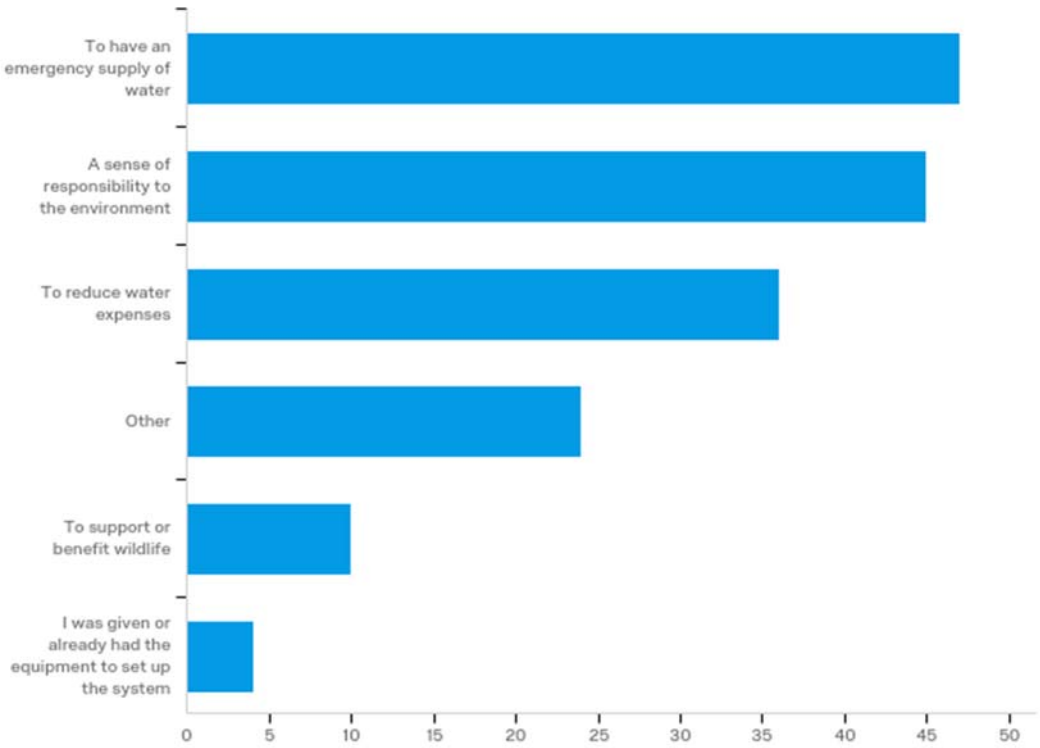


Figure 24. Factors that influenced respondents to practice rainwater harvesting (Q14, *n* = 101.

population in Utah are members of The Church of Jesus Christ of Latter-day Saints (LDS; Canham, 2014), a religion that strongly encourages emergency preparedness. Promoting emergency preparedness may not be the top strategy for encouraging RWH in other places, but it may be at least one of the top strategies in Utah. Such a promotion could be framed in terms of fire prevention and preparedness as well.

In agreement with responses to other questions (Q4 & Q12), "A sense of responsibility to the environment" was also an important factor in convincing respondents (44.5%) to begin harvesting rainwater. Reducing water expenses was the next highest response (35.64%). The "other" category (23.76%) again included a range of responses on various topics (see Appendix C).

Q15 - Does harvesting rainwater cause you to try to conserve water in other areas of your life?

As Figure 25 illustrates, 55% of respondents said that harvesting rainwater causes them to conserve water in other areas of their lives. In harvesting rainwater, one naturally monitors how much water they are collecting. This causes them to think more their water use in other areas of their lives, and then, at least some take actions to reduce their water use in general. Several people, however, said that harvesting rainwater did not cause them to try to conserve water in other areas of their lives (23.53%) and similar numbers said they were not sure, one way or the other (20.59%).

In sum, while most respondents reported concern for the environment, it is likely that most Utahans do not understand how significant their outdoor water use is compared to

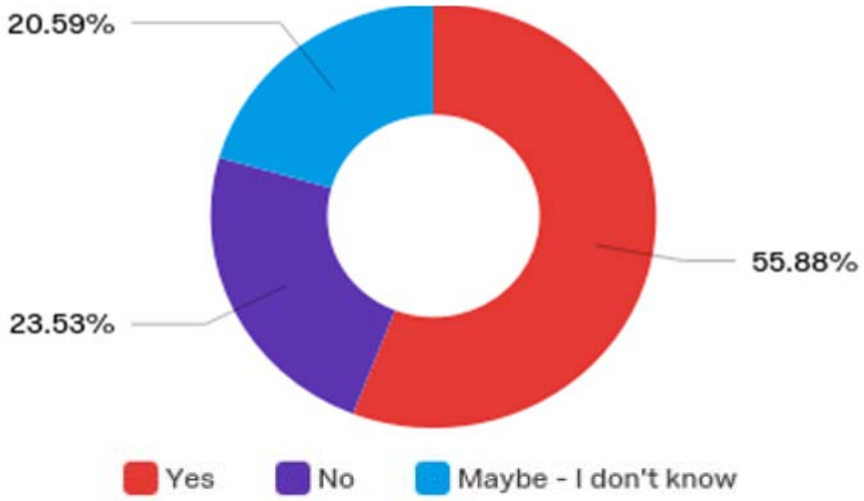


Figure 25. Influence of rainwater harvesting on other forms of water conservation (Q15, *n* = 102).

their indoor water use. It is evident from several of the survey responses that educating the public about the facts of conservation and the impact their efforts can have is one of the most important things for those who wish to promote RWH and conservation in general to focus on. It is also evident that RWH, like any other conservation effort, is not a solitary activity. It is natural for conservation efforts to be connected in some way; promoting one type of conservation behavior will most likely lead to an increase in others. Even though RWH may not be a silver bullet that will solve all of the water issues in Utah or throughout the west, promoting it will have beneficial impacts in conservation efforts overall.

Examination of the Law Concerning RWH: Senate Bill 32

As was stated in the review of the literature, Utah residents have been able to legally harvest rainwater since 2010. While this change in the law is a good one, and

certainly a step in the right direction, the law still needs to be reviewed and adjusted if Utah residents are going to utilize RWH to its fullest potential.

Unsurprisingly, most Utahans have not actually read the law thoroughly. It appears that the new law is highly misunderstood and, understandably, likely even disregarded to some degree. For instance, the law states that residents may collect up to 200 gallons of rainwater in as many as two covered containers, presumably above ground, but if they want the ability to store more than 200 gallons, according to the law, it must be done with only one underground storage container (see Appendix D). However, the majority of the survey respondents have storage capacity well over 200 gallons and almost half (49.02%) of them said that their RWH storage system is above ground. The law seems to be unclear and unfamiliar even to those who are currently harvesting rainwater. As a result, it appears that people install their RWH system as they see fit and however it best suits their needs. If it weren't for the stipulations in the law, this would be ideal. However, the law is written in a restrictive manner with unhelpful limitations that make it difficult to adopt RWH and apply it to a variety of households, each with a unique location and situation. If RWH is to be adopted on the larger scale that is needed to improve water conservation and mitigate water shortages throughout Utah, the law should be changed so as to be more enabling.

Senate Bill 32 also states that those who will be harvesting up to 2,500 gallons below ground need to register with the DWRi, but in the section covering those who will be harvesting less than 200 gallons, it does not mention registration (see Appendix D). This seems to imply that those who are only harvesting 200 gallons or less do not need to

register. If this is how the law was meant to be written, something should be done with the registration website to restrict those with very small RWH systems from registering or at least inform them that they do not need to register. If this were done, the list of registrants would be much more manageable and useful. On the other hand, if it was intended for every person who adopts RWH to register with the DWRi, it should have been written more explicitly in the law.

Currently, anyone can register as a rainwater harvester no matter the size of their storage tank, and regardless of whether they are actually harvesting or not. One person, when registering with the DWRi, even reported that they would be harvesting "a thimble full." It is obvious that because registration with the DWRi is not monitored or enforced, it is not taken completely seriously by some of those who register. Additionally, it is also possible that there are many people who are harvesting rainwater but who have not yet registered with the DWRi; they either don't know that they are supposed to register or they have chosen not to. This is not a new problem—people were harvesting rainwater well before 2010 even though it was not legal. They either didn't know of its illegality or chose to practice RWH regardless because there was no enforcement of it then any more than there is now. One survey respondent stated (Q7) that they began harvesting rainwater 40 years ago to avoid using hard tap water for their house plants.

The issues surrounding registration with the DWRi seem to imply that the registration website is not accomplishing all that it was meant to. It begs the question of why harvesters need to register in the first place. The cooperation of the DWRi in this research has been greatly appreciated, as this study has relied solely on the registration

list, but it is unclear what other good comes from it. This is likely due to the fact that it is difficult to ensure that everyone who should be registered actually is and that the information they provide is accurate and useful. Furthermore, the requirement to register may be doing more harm than good. Some people may be under the impression that registering with the DWRi is synonymous with obtaining a license to harvest rainwater and may be intimidated by the process or unwilling to engage in rainwater harvesting if they perceive that it means more government interference and control.

An additional issue in the law that seems to lack a logical foundation is the limit on storage capacity. Utah is the only state in the west that imposes a maximum amount that one can harvest (Loper, 2015). USU Extension says it is possible to harvest up to 5,000 gallons of rainwater from an average roof in Utah (USU Extension, 2016), yet the law limits storage capacity to 2,500 gallons. Why does the law limit capacity to half of the potential to be harvested? Some might argue that harvesters would never collect all the rainwater throughout a year before dispensing it again in their landscape and could therefore get by with a smaller storage tank. They might actually harvest 5,000 gallons or more throughout the year but only store 2,500 gallons at any given time. However, with most of the rain coming in the spring, it is possible, and likely, that a 2,500-gallon tank could be full in the early spring, before the water is needed and/or able to be used in the landscape. After taking the survey, one respondent included through an additional email: "My 2,000-gallon rain water collection tank doesn't do me much good. It overflows most of the year when I don't need it. Then when I do need it, I deplete it quickly and it remains dry most of the summer when I really need water."

If up to 5,000 gallons could be harvested on an average roof—1000 square feet according to USU Extension (USU Extension, 2016)—how much more could be harvested from the multitudes of above-average roof sizes that are scattered throughout the state? If there must be a limit to storage capacity, instead of setting an arbitrary maximum—2,500 gallons—it would make more sense if it were connected to one's potential amount to harvest; the square footage of one's collection surface could be multiplied by their location's average rainfall to determine the most logical size of storage tank.

The 2,500-gallon limit on RWH storage capacity should be removed from the law. If harvesters were allowed to have whatever storage capacity they desire, in most cases, their RWH system would do more good. It would allow people to have the supply they need to actually make harvesting rainwater a worthwhile expense and practice. Larger tanks would also help prevent reaching full capacity and then overflowing during the spring and early summer when the most precipitation is received.

The law concerning RWH is written in a way that is restrictive and limiting in ways that do not make much sense nor encourage people to begin harvesting rainwater. Removing the current legal barriers to RWH could be a more impactful strategy to encouraging more people to harvest rainwater than reducing the cost might be. If legislators really wish to promote RWH as a tool in conservation, the law should be revised in order to be more enabling instead of restrictive. This would hopefully encourage more people to adopt RWH and also potentially bring about a greater benefit to all harvesters and society at large.

CHAPTER V

SUMMARY OF RESULTS AND RECOMMENDATIONS

Having a better understanding of the main motivations behind current harvesters' decision to practice RWH will significantly assist future attempts to encourage other Utahans to adopt these practices. In light of the top two influencing factors being an emergency supply of water and a concern for the environment, with financial savings being a close tertiary influencer, the best strategy going forward seems to be to develop a better system to educate people on the critical nature of Utah's water scarcity, including how, if it were adopted by enough people, RWH has the potential to make a significant impact on the environment as well as augment our scarce water resources. From there, encouraging RWH as an effective and efficient means to build up a reserve of water in case of emergency would also be beneficial. Finding ways to reduce costs of RWH system components and installation is also important.

Limitations of Research and Possible Solutions

The sample size of this study was unfortunately small. However, this is largely a result of the fact that the potential sample pool of rainwater harvesters was also extremely small in comparison to the general population in Utah. The only way to mitigate this would be to wait for more people to register with the DWRi. A similar survey could be performed in the future after more people have registered that could determine, among other things, if the motivations of rainwater harvesters have changed and how successful

our efforts to promote RWH have been.

The verbiage of some of the questions in the survey could have been revised and clarified to get more accurate responses. For example, in Q7, had "other garden plants" been included with "To water Vegetable garden(s)," a number of the responses in the "Other" category could have been grouped in that choice, although it wouldn't have affected the results by a significant margin. While a good deal of time was spent in making sure the survey questions were clear and concise and were actually targeted at the specific issue at hand, some of the respondents either did not understand certain questions fully or interpreted them differently than had been intended. Had a pilot survey been completed previous to sending the survey to the entire list of rainwater harvesters, some of these issues might have been worked out, but it is still highly unlikely that all of them could have been avoided. There were not any questions that appeared to be misunderstood or misinterpreted by the majority of respondents and so all results were analyzed as they were given.

Opportunities for Future Research

There is a great need for future studies in RWH and water conservation in general. In particular, several of the results presented here could be explored further in order to better focus in on what could be done in Utah to promote RWH and conservation.

It would be wise and likely very beneficial to survey a sample of Utah residents who are presumably not harvesting rainwater to find out why they choose not to adopt

RWH and compare those results to that of this research. Such a study and comparison has the potential to reveal more knowledge of what could be done to mitigate or remove the barriers that keep more people from harvesting rainwater.

More detailed and accurate data on the costs of RWH systems specific to Utah is needed. There is extensive information in the *Texas Manual on Rainwater Harvesting* (Krishna, 2005) but it is, justifiably, specific to Texas. Much of the material in the manual is valuable no matter the location, but some of it is not directly applicable to Utah.

This research should not stand alone and should not be the terminus of exploration into RWH and conservation in Utah. RWH has great potential but it will need to be examined a great deal more before it will do the good on a widespread basis that we hope it will.

Conclusion

The main objective of this thesis has been to determine what motivates Utah residents to harvest rainwater. With the knowledge presented here, it is anticipated that planners, water districts, water managers, cities, state agencies, and legislators concerned with water resources and conservation, and anyone trying to promote RWH, will be able to develop more effective strategies to encourage greater numbers of the general population in Utah to adopt the practice of RWH and increase efforts of conservation in general. This thesis has also reviewed the current laws concerning RWH and how they affect those who choose to harvest rainwater, as well as those who strive to promote it

and encourage others to adopt the practice. It has been found that the laws and regulations concerning RWH should be reexamined and adjusted by the state legislature in order to make it easier to practice RWH and encourage others to do so as well.

The water that we have in this dry state of Utah is very limited and, therefore, our most precious resource. Every possible effort should be taken to ensure that it is preserved and protected for the generations that will need it in the future. RWH is one of those efforts that should be explored, studied, and encouraged further.

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APPENDICES

Appendix A

Correspondence with Survey Participants

Recruitment Email

Dear Rainwater Harvester,

You have received this email because you have registered with the Utah Division of Water Rights (DWRi) as a rainwater harvester who is collecting more than 500 gallons of rainwater.

My name is Wayne Honaker and I am a graduate student at Utah State University. As part of my graduate research, my advisor and I are studying rainwater harvesting throughout the state of Utah, and what motivates individuals such as yourself to begin harvesting rainwater. Please assist us in this research by completing the online survey at the link below. The survey link will be available until April 21, 2017 for your convenience.

As Utah moves into the future, rainwater harvesting has the potential to play an increasing role in ensuring that we each have the water we need. Our hope is that by understanding more about what has motivated you to harvest rainwater, we will be better able to encourage others, throughout the state, to do the same. Your assistance in this research by completing the survey is greatly appreciated.

Please be aware that this research has been approved by the USU Institutional Review Board (IRB) under protocol #7509 and that all personal identifying information will be removed from your responses to the survey and that the data gathered will only be analyzed in composite. If you have questions or concerns about this research you may contact us at the addresses provided below.

Thank you!

Wayne Honaker, Graduate Student Researcher
Landscape Architecture & Environmental Planning
Utah State University
wayne.honaker@aggiemail.usu.edu

Phillip S. Waite, Associate Professor
Landscape Architecture & Environmental Planning
Utah State University
435-797-0504 // ps.waite@usu.edu

link to survey

Email Expressing Appreciation for Completing the Survey

Dear Rainwater Harvester,

Thank you for completing the survey on your motivations for harvesting rainwater. We have received a good number of responses and will be compiling the results throughout the next few months. Your assistance in this research is greatly appreciated. If you have any further questions about our research, feel free to contact us at the addresses below. Thanks again!

Wayne Honaker, Graduate Student Researcher
Landscape Architecture & Environmental Planning
Utah State University
wayne.honaker@aggiemail.usu.edu

Phillip S. Waite, Associate Professor
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Utah State University
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Page 1 of 2
Protocol #7509
IRB Approval Date: 3/22/2017
Consent Document Expires: 3/21/2020
IRB Password Protected per IRB Coordinator

v.8 2.24.2016

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Letter of Information

An Examination of What Motivates Utah Residents to Adopt the Practice of Rainwater Harvesting

Introduction You are invited to participate in a research study conducted by Phillip S. Waite, an Associate Professor in the Landscape Architecture and Environmental Planning Department at Utah State University. The purpose of this research is to determine the motivations of Utah citizens in choosing to harvest rainwater. This form includes detailed information on the research to help you decide whether to participate in this study. Please read it carefully and ask any questions you have before you agree to participate.

Procedures Your participation will involve taking an online survey. The survey contains 23 questions about your experience collecting rainwater and your participation in this project is expected to take 15 minutes. We anticipate that 300 people will participate in this research study. As a follow up for this survey, we may also conduct interviews and request to take photos of your rainwater harvesting methods. We will followup with the same group of individuals we reached out to for participation in this component of this study with a second consent document and more information at that time.

Risks This is a minimal risk research study. That means that the risks of participating are no more likely or serious than those you encounter in everyday activities. While there is a risk of loss of confidentiality, we will take steps to minimize these risks (outlined below).

Benefits There is no direct benefit to you for participating in this research study. More broadly, this study will help the researchers learn more about rainwater harvesting in Utah and may help others adopt rainwater harvesting as one of many possible sustainable practices.

Confidentiality The researchers will make every effort to ensure that the information you provide as part of this study remains confidential. Your identity will not be revealed in any publications, presentations, or reports resulting from this research study. We will collect your information through an online Qualtrics survey. This information will be securely stored in a restricted-access folder on Box.com, an encrypted, cloud-based storage system or in a locked drawer in a restricted-access office. It is unlikely, but possible, that others (Utah State University or state or federal officials) may require us to share the information you give us from the study to ensure that the research was conducted safely and appropriately. We will only share your information if law or policy requires us to do so. Any personally identifying information will be deleted by March 2020. De-identified data will be kept by the research team.

The research team works to ensure confidentiality to the degree permitted by technology. It is possible, although unlikely, that unauthorized individuals could gain access to your responses because you are responding online. However, your participation in this online survey involves risks similar to a person's everyday use of the Internet.

Voluntary Participation & Withdrawal Your participation in this research is completely voluntary. If you agree to participate now and change your mind later, you may withdraw at any time by notifying the principal investigator, Phillip S. Waite via email at ps.waite@usu.edu. If you choose to withdraw after we have already collected information about you, we will, to the extent possible, remove your data from the study. But please note that completely anonymous participation cannot be withdrawn as we will be unable to determine whose data is whose. There is no cost to you to participate in this study except for the time involved.

Compensation There is no payment or compensation for your participation in this research study.

IRB Review The Institutional Review Board (IRB) for the protection of human research participants at Utah State University has reviewed and approved this study. If you have questions about the research study itself, please contact the Principal Investigator at 435-797-0504 or ps.waite@usu.edu. If you have questions about your rights or would simply like to speak with someone other than the research team about questions or concerns, please contact the IRB Director at (435) 797-0567 or irb@usu.edu.

Phillip S. Waite
Principal Investigator
(435) 797-0504; ps.waite@usu.edu

Wayne Honaker
Student Investigator
435-797-0500; waynehonaker2584@gmail.com

Informed Consent By clicking "Agree" you agree to participate in this study and indicate you are at least 18 years of age or older. You indicate that you understand the risks and benefits of participation, and that you know what you will be asked to do. You also agree that you have asked any questions you might have, and are clear on how to stop your participation in the study if you choose to do so. Please be sure to retain a copy of this form for your records.

Email Correspondence with Survey Participants (Original spelling and grammar preserved)

April 13
Wayne, I am interested in data on the content of the water/snow collected. Can I get copies of that data from you?
Carl Kem
student, Snow College

April 10
Thank you for the appreciation note, Wayne. Today's comment: I'm sure glad my barrels were in place today. They filled in about an hour of runoff from a roof-load of that wet, heavy snow.
Tod

April 10
You are very welcome, glad to be of assistance
Hope your project goes well
The Kilgores

April 5
The choice to save rainwater should be self-evident. No study should be necessary.

I choose to save rainwater because it is one of the few rights left in this country. This nation was founded on principles of Liberty. The sole purpose of government is to protect our God-given rights. Yet, these days, instead of government being the servant, it is becoming the master. I look forward to, depend upon, and believe in good, limited government, as prescribed by our Founding Fathers. See: "The 5,000 Year Leap," by W. Cleon Skousen - nccs.net.

I choose to save rainwater to be self-reliant - an art few know or understand in our modern day. All water saved is returned to the soil, as if it fell there from the sky.

I choose not to complete the survey. Thanks for your interest, time and effort. I appreciate what you are trying to do.

April 5
Wayne,
If you recall, I emailed you a couple of weeks ago to let you know that I applied for the permit but I don't yet have a harvesting system in place.
Mike Smith

April 5
Your link does not work. Just "worls"

April 5
I tried taking your survey, but gave up. I find it flawed in that it doesn't give me the option to select multiple options where the case might be warranted (how do you store your rainwater: pond, closed plastic container, etc). I use multiple methods. Additionally, earlier you asked two different questions but left room for only one answer. How much rain water do you collect, how much rain water did you register you'd be collecting with the state. Might want to reconsider how you have the survey set up.

-Jamie Cummings-

April 5
SECOND REPLY. WE DID NOT DO ANY RAIN BARRELS
DEBBIE

March 30
Wayne
we simply plan on collecting rain water for conservation: using the water to augment municipal supplies for outdoor plants. In addition we are going to plant buffalo grass which requires virtually no watering once established. Water will increasingly be a precious commodity here in the west.
Utah requires "registering" when one expects to collect more than 100 gallons. Note two 55 gallon rain barrels off the down-spouts exceeds that level. One inch of rain on our ~2200 square foot roof would exceed 1000 gallons. So why pay to have municipalities collect runoff, process the water, and distribute it back to where it fell in the first place?

March 29
Wayne, the reason I haven't responded to your survey is that, even though I signed up for rainwater harvesting, I haven't yet begun to do so. I have yet to get my shop and rain water harvesting system set up.
I have a great day,
Mike Smith

Mike,
Thanks for your email. We understand and will try not to bother you again. Good luck

getting your system up and running. I hope it goes well.
Thanks.

March 29
This business ceased operations in 2014.
Cynthia Kofford

Cynthia,
Thank you for your email. I did get the first one you sent but the reminder email was automatically generated and I neglected to take your name off the list. Sorry to bother you again.

March 27
I received your survey from Seth Bockholt, the landscape architect that helped develop the plan for our rainwater harvesting system. We're a little different than the typical user in that we are a small residential development (echospur.com) and have installed 5 rainwater systems (one for each house built to date). I'd be glad to answer any additional questions about the systems and what motivated us to do it.
By the way, one of your questions (they Why? question) should also include "managing stormwater runoff" as a motivation for the install. Park City, as well as other municipalities, have been required by the EPA to upgrade stormwater management and are imposing fees on homeowners. We're negotiating with the City for a fee reduction based on our tanks and Green Roof systems.
Best,
Sean

Sean Kelleher, CFA
(m) 9734523727

March 26
Wayne,
Your survey got me thinking that you have not even considered the most practical and biggest solutions for preserving our potable water resources. I thought I would take a moment to share some ideas that are not even alluded to in your survey.

First of all my 2000 gallon rain water collection tank doesn't do me much good. It overflows most of the year when I don't need it. Then when I do need it, I deplete it quickly and it remains dry most of the summer when I really need water. I'm perplexed with respect to what I should be doing to accomplish my objectives (grow fruit trees, vegetables, and berries to be more self reliant and save money in the long run, I'd also like to have a nice looking yard).

As I filled out your survey, I felt strongly that I don't see water shortage problems the same way that you do. Here in Salt Lake City we use great potable water for everything including watering outside landscapes.Watering yards requires a lot more water than

anything we do inside and we pay a hefty price to water our yards. It seems cheaper to let others outside of Salt Lake County or out of state, to water and grow our food, pick, store, ship, advertise, display in magnificent retail stores, and sell us our fruit and vegetables than than for us to pay for the water to grow them locally. Most people in Salt Lake county are being forced to use high quality potable water to irrigate their yards and grow their gardens. I can't back this up with statistics by I hypothesize that requiring everyone to only use dual flush toilets, low flow shower heads, low flow aerators, and be more frugal in their habits would not come close to off-setting the amount of water used to irrigate yards.

I wish I could use dirty or gray water for irrigating my yard and save all the high quality drinking water for inside the house. Davis county has secondary Weber water they can use for outside landscapes. However most of us here is Salt Lake County have no other options. We have to use high quality tap water for irrigating. And if we use very much of it, the price is high.

The ironic thing is that where I live, I'm surrounded by an incredible amount of dirty water that I'm prohibited from using. The water table is about 7' to 12' down all year long. I know because I have to pump it out to protect a basement sometimes during the year, so I monitor the water level. City Creek (the river) is hidden under the North Temple one half block from my house and dumps into the Jordan River about three blocks away. All that great high quality potable water that is used through out the valley is NOT destroyed. It just becomes dirty. It's then processed or cleaned and again dumped into the Jordan River. I even have an artesian well that the state says I don't own and they are trying hard to take from me. We are surrounded by an incredible amount of dirty water that we are prohibited from using to irrigate. To be fair, the plumbing code does allow us to recycle our own gray water and use that for irrigating our yard,s but it is expensive to set those systems up.

I am trying to understand the serious water issues as are you. I don't pretend to understand everything even for my little part of the world. But most of the earth is covered by water. There is not a shortage of water on the earth. The amount of water in the world is not decreasing. It's not always were we need it. Most of the earth's water is too contaminated or dirty for human consumption. But why does the government not allow us to use and make it easier to use dirty water for irrigating our yards and save that high quality potable water for inside houses and buildings where it is really needed? Why not make it easier to use dirty or substandard water for our yards. That would conserve and protect our potable water.

I am grateful that the government is allowing us to use some rain water for irrigating but that is just throwing us a bone. It isn't a real great solution to our water problems. It's a distraction to keep us all from coming up with real solutions.

I'm grateful that the government is allowing us to reclaim our grey water and use it for

irrigating but very few people will ever be able to afford to do it. If everyone kept their grey water from running down the sewer and used it themselves, I don't believe there would be enough water to transport the toilet water to the sewer treatment plant and city sewers pipes would be clogging everywhere. I believe we need a lot of water running through sewers to keep them flowing. I believe that sewer districts should set up secondary water systems and let us water our yards with that processed water. That would save and protect our precious potable water for where it is really needed. I know that secondary water systems are expensive to install but not near as expensive as it is for everyone to create their own reclaimed water system.

Your survey questions led me to believe that you don't realize how much government regulation and policy damages our potable water supply.

Respectfully and best wishes to you on your project,
Rod Olsen
Plumbing Contractor, General Contractor, Real Estate Broker

March 23
When I clicked on the survey the first page asks me to agree to a letter of information, but the letter is not showing.
Kindly,
Jacob

Jacob,
I've attached the letter if information below. I'm not sure why it isn't showing up for you but I will look into it. If you see the radio buttons that are below where the letter should be you should still be able to move forward with the survey. Let me know if you continue to experience further trouble. Thank you.

March 23
we have not done this but are still looking into setting up barrels in back yard.
debbie

March 23
The application to take the survey is not available through my computer, therefore, I will not be able to help you out.

March 22
The business that this pertained to has closed so I can't help you.
Cynthia Kofford

March 22
...is this survey mobile friendly?

John,
We've tried to make it mobile friendly. It might look a bit different than it would on a computer but it should work. Are you having trouble accessing it?

Hi bro. Thanks for the response. I can't maneuver on my phone. I'll try my desk top and see.

March 22
Not collecting water yet
dennis
201.803.5696

March 22
Excellent! Should have been done decades ago!

We face the old ways of the West where all of the water belongs to - now - "The State." We do not pay enough attention to conservation, storm water retention & use and the "right" of a property owner to the water that falls upon 'his' property.

Thank you for investigating.
T. Young

March 22
We registered but have not started to harvest yet. We are in the process of building a building and wanted to water our trees and shrubs because we don't have access to secondary water. We will not be finished with our building until June or July.
Thanks,
Jerry

Jerry Garrett
President
Jerry's Plumbing Specialties
2679 Midland Drive #1
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Appendix B

Quantitative Results of Survey

Quantitative Results of Survey

Q1. Please carefully review the Letter of Information below before deciding to continue with this survey.

#	Answer	%	Count
1	Agree. I will participate in this research by taking this survey and I am at least 18 years of age.	94.02%	110
2	No. I do not wish to participate and/or I am younger than 18 years of age.	5.98%	7
	Total	100%	117

Q2. What is the capacity of your rainwater harvest and storage system in gallons? (When you registered with the Utah Division of Water Rights (DWRi) as a rainwater harvester, how many gallons did you indicate you would be harvesting?)

Answer	%	Count
No Data Provided	3.9%	4
Less than 500 Gal.	12.7%	13
500-999 Gal.	26.5%	27
1000-1499 Gal.	13.7%	14
1500-1999 Gal.	2.9%	3
2000-2499 Gal.	11.8%	12
2500 Gal. (max)	28.4%	29
Total	100.0%	102

Q3. Where & how did you learn that you needed to register your rainwater harvesting activity with the Division of Water Rights (DWRi)?

#	Answer	%	Count
1	When Utah Senate Bill 32 was passed in 2010	16.35%	17
2	While Visiting the DWRi website	25.96%	27
3	My friend/neighbor told me	16.35%	17
4	When I purchased my rainwater storage tank	1.92%	2
5	Through communication from my city (email/newsletter)	3.85%	4
6	Other	35.58%	37
	Total	100%	104

Q4. Are your main reasons for harvesting rainwater economically/financially motivated or environmentally motivated?

#	Answer	%	Count
1	Definitely economically/financially motivated	10.89%	11
2	Probably economically/financially motivated	8.91%	9
3	Both economically/financially motivated and environmentally motivated	51.49%	52
4	Probably environmentally motivated	5.94%	6
5	Definitely environmentally motivated	22.77%	23
	Total	100%	101

Q5. Please indicate the range of what you paid for your rainwater harvesting system (please include the cost of equipment and supplies as well as installation, if applicable)

#	Answer	%	Count
1	$0 - $500	60.82%	59
2	$501 - $1000	16.49%	16
3	$1001 - $1500	5.15%	5
4	$1501 - $2000	3.09%	3
5	$2001 - $2500	5.15%	5
6	$2501 - $3000	1.03%	1
7	$3001 or above	8.25%	8
	Total	100%	97

Q6. What method do you use for storing the rainwater you have harvested?

#	Answer	%	Count
1	An open tank, pond, or otherwise open water feature	5.88%	6
2	An above-ground closed plastic tank	42.16%	43
3	An above-ground closed metal tank	0.98%	1
4	An above-ground closed concrete or masonry tank	0.00%	0
5	A below-ground closed plastic tank	20.59%	21
6	A below-ground closed metal tank	0.00%	0
7	A below ground closed concrete or masonry tank	8.82%	9
8	Other	21.57%	22
	Total	100%	102

Q7. How do you use the water that collects in your rainwater harvesting system? Please select all that apply.

#	Answer	%	Count
1	To water turf-grass	11.19%	33
2	To water trees & shrubs	19.66%	58
3	To water vegetable garden(s)	24.75%	73
4	To attract or support wildlife in the area	4.75%	14
5	To support domestic animals (dogs, cats, etc.)	5.08%	15
6	For culinary purposes (to drink and cook with)	1.02%	3
7	To wash laundry/shower with	2.37%	7
8	For an emergency supply	14.24%	42
9	As a reserve for fire protection	4.07%	12
10	To supplement a decorative amenity (water garden/fountain)	3.73%	11
11	To wash vehicles	1.36%	4
12	Other	7.80%	23
	Total	100%	295

Q8. On a scale of 1 to 10, how beneficial do you feel your rainwater harvesting system is for the purposes you listed above? - 1=low benefit; 10=high benefit

Minimum	Maximum	Mean	Std Deviation	Variance	Count
0	10	7.63	2.54	6.46	99

Q9. Who installed your rainwater harvesting system?

#	Answer	%	Count
1	I installed it myself	73.00%	73
2	A friend, neighbor, or relative installed it for me	2.00%	2
3	I paid a professional to install it	8.00%	8
4	Other	17.00%	17
	Total	100%	100

Q10. Who performs the maintenance on your rainwater harvesting system?

#	Answer	%	Count
1	I maintain the system myself.	88.78%	87
2	A friend, neighbor, or relative maintains the system for me.	1.02%	1
3	I pay someone else or a company to maintain the system.	1.02%	1
4	Other	9.18%	9
	Total	100%	98

Q11. Would you install your rainwater harvesting system again if you had that choice?

#	Answer	%	Count
1	Yes	91.84%	90
2	No	3.06%	3
3	Maybe	5.10%	5
	Total	100%	98

Q12. How important is conserving water in general to you personally?

#	Answer	%	Count
1	Extremely important	40.59%	41
2	Very important	35.64%	36
3	Moderately important	16.83%	17
4	Slightly important	2.97%	3
5	Not at all important	3.96%	4
	Total	100%	101

Q13. Please rank the following items in order of what you feel could be done in your household to have the greatest impact in conserving water. (drag & drop to reorder)

		%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	
1	Shorter shower times	11.6%	11	15.8%	15	17.9%	17	19.0%	18	23.2%	22	6.3%	6	6.3%	6	0.0%	0	95
2	Increasing laundry & dishwasher load sizes	0.0%	0	5.3%	5	20.0%	19	26.3%	25	17.9%	17	26.3%	25	3.2%	3	1.1%	1	95
3	Adjusting landscaping sprinklers and setting sprinkler timers correctly	23.2%	22	26.3%	25	15.8%	15	20.0%	19	8.4%	8	6.3%	6	0.0%	0	0.0%	0	95
4	Replacing lawn areas with shrubs and perennial plants	26.3%	25	16.8%	16	12.6%	12	16.8%	16	11.6%	11	10.5%	10	5.3%	5	0.0%	0	95
5	Harvesting Rainwater	24.2%	23	20.0%	19	11.6%	11	8.4%	8	17.9%	17	11.6%	11	5.3%	5	1.1%	1	95
6	Installing dual-flush toilets	3.2%	3	10.5%	10	14.7%	14	7.4%	7	16.8%	16	30.5%	29	16.8%	16	0.0%	0	95
7	Eating less meat	4.2%	4	3.2%	3	5.3%	5	2.1%	2	4.2%	4	6.3%	6	57.9%	55	16.8%	16	95
8	Other	7.4%	7	2.1%	2	2.1%	2	0.0%	0	0.0%	0	2.1%	2	5.3%	5	81.1%	77	95

Q14. What is the largest factor(s) that influenced you to begin harvesting rainwater? (Please select all that apply).

#	Answer	%	Count
1	A sense of responsibility to the environment	27.11%	45
2	To reduce water expenses	21.69%	36
3	To support or benefit wildlife	6.02%	10
4	To have an emergency supply of water	28.31%	47
5	I was given or already had the equipment to set up the system	2.41%	4
6	Other	14.46%	24
	Total	100%	166

Q15. Does harvesting rainwater cause you to try to conserve water in other areas of your life?

#	Answer	%	Count
1	Yes	55.88%	57
2	No	23.53%	24
3	Maybe - I don't know	20.59%	21
	Total	100%	102

Q16. What is your gender?

#	Answer	%	Count
1	Male	84.31%	86
2	Female	15.69%	16
	Total	100%	102

Q17. What is your age?

#	Answer	%	Count
1	18 - 24	0.00%	0
2	25 - 34	14.71%	15
3	35 - 44	19.61%	20
4	45 - 54	16.67%	17
5	55 - 64	31.37%	32
6	65 - 74	12.75%	13
7	75 - 84	3.92%	4
8	85 or older	0.98%	1
	Total	100%	102

Q18. What is the highest level of formal education you have completed or the highest degree you have received?

#	Answer	%	Count
1	Less than high school	0.98%	1
2	High school graduate	2.94%	3
3	Some college	17.65%	18
4	2 year degree	6.86%	7
5	4 year degree	34.31%	35
6	Professional degree	27.45%	28
7	Doctorate	9.80%	10
	Total	100%	102

Q19. What is your employment status?

#	Answer	%	Count
1	Employed full time	69.61%	71
2	Employed part time	2.94%	3
3	Unemployed looking for work	2.94%	3
4	Unemployed not looking for work	3.92%	4
5	Retired	16.67%	17
6	Student	1.96%	2
7	Disabled	1.96%	2
	Total	100%	102

Q20. Information about income is very important to understand. Please indicate your best estimate of your entire household income in 2016 before taxes.

#	Answer	%	Count
1	$0 - $30,000	7.00%	7
2	$30,001 to $60,000	14.00%	14
3	$60,001 to $90,000	29.00%	29
4	$90,001 to $120,000	17.00%	17
5	$120,001 to $150,000	15.00%	15
6	More than $150,000	18.00%	18
	Total	100%	100

Q21. How would you describe the environmental context where you live?

#	Answer	%	Count
1	Urban	23.76%	24
2	Somewhat urban	7.92%	8
3	Suburban	43.56%	44
4	Somewhat rural	8.91%	9
5	Rural	15.84%	16
	Total	100%	101

Q22. How would you describe your political views?

#	Answer	%	Count
1	Very Liberal	7.92%	8
2	Liberal	11.88%	12
3	Moderate	32.67%	33
4	Conservative	29.70%	30
5	Very Conservative	17.82%	18
	Total	100%	101

Q23. As was stated in the email you received, all personal identifying information will be removed from your responses to this survey. However, as we continue this research, we may have other questions. May we contact you again in the future to inquire further about your rainwater harvesting system?

#	Answer	%	Count
1	Yes (Please provide an email address or phone number where we may contact you in the future)	66.34%	67
2	No	33.66%	34
	Total	100%	101

Appendix C

Written Responses for Q3, Q6, Q7, Q9, Q10, Q13, and Q14

The following are written responses to the questions that contained an "other" category. (Spelling and grammar has been preserved as it was originally recorded.)

Q3. Where & how did you learn that you needed to register your rainwater harvesting activity with the Division of Water Rights (DWRi)?

Research on different states water laws
research
architect when building a new home
internet article
Google search on rainwater harvesting in Utah
My architect
Through a class at the University of Utah
story on facebook
Alot of research
Google
Radio news story
Researching online
Google search
Common knowledge in the landscape industry.
newspaper
Through research about rainwater collection online
Salt Lake County
Son works for Dept. of Interior
News media
I can't remember
I worked with legislators to get the bill passed.
Facebook
imternet research
Regulation Research for current property. Chicken keeping was not allowed, so I went with rain water.
Master Gardener program
google searches
internet surfing
I don't recall
Researched if I could
Personal Research, I wanted a living water storage for emergencies.
the internet
gossip/hippies
google search
News

Q6. What method do you use for storing the rainwater you have harvested?

none
An open pond plus 7 open plastic garbage cans
above-ground plastic tank AND open pond/water feature
I do not have a system now but plan to have a closed tank of plastic to avoid rust.
both above ground plastic and below ground concrete
I don't actually harvest rainwater, I only registered to make work for the government office that maintains the records
Filtered,Collected and distributed to multiple above-ground closed plastic storage tanks totaling less that 2500 gallons located at point of use on an off grid cabin property
I didn't do it; I didn't build the house.
I have not installed it yet. I acquired the certificate in advance.
an above ground closed bladder
above ground closed and open plastic tanks
I haven't installed one yet
33% elevated BPA-free funnel fed plastic storage unit.
below ground but no idea on tank material
None
55 gallon drum
let it run onto the lawn
I have not installed a system or harvested any water.
Not yet installed.
None yet
Above ground rain barrel system
Will use below ground plastic cistern

Q7. How do you use the water that collects in your rainwater harvesting system?

Have not decided yet
Reserve water
I will have to test the water to see if it will work for vegetable gardens because of the asphalt content of my roof.
I believe the requirement to Register is stupid, and i wanted to create a little bit of extra work for a useless government burocracy with no cost to myself
there is no water in the area, no way to purchase water rights. What else can I use?
non-directed overflow to existing vegetation
To water horses
For toilet in cabin
Not yet installed
None yet
This is on an off-grid property that has no well available, so the rainwater is used for almost everything except drinking water. This may not reflect the answers correctly intended on the rest of the survey as a whole
Wine grape vineyard
hose patio, water patio plants
aquaponics garden and fisk tanks
Pasture
To water indoor plants year-round.
To water house plants. This was our original motive for collecting rainwater about forty years ago. Our tap water is very hard; calcium carbonate encrusted the soil in our pots when we used tap water.
Landscape Water Features
As a heat sink to cool my wine cellar in the winter
livestock
irrigate Green Roof

Q9. Who installed your rainwater harvesting system?

Have not installed yet
have not installed one
not done yet
My husband & I installed it together.
I haven't installed it yet.
i don't have any equipment
Not yet installed...but will be self installed.
Not
I have olny IBC Totes and 55 gal. drums for now
paid builder - while building remote cabin
No one
Not installed yet
Installing this summer
Not yet installed
None yet
I will when I purchase the tank

Q10. Who performs the maintenance on your rainwater harvesting system?

No system
No maintenance has been required at this point
I would maintain it.
None, it is not installed yet
Not yet installed, but will be maintained by myself.
pump broke, but overflow and gravity does the watering
No one
Not yet installed

Q13. Please rank the following items in order of what you feel could be done in your household to have the greatest impact in conserving water.

Cities allowing desert landscape
Collect Gray Water for irrigation
Eating food I produce instead of the water heavy food from grocery stores.
eating less meat???
Eating more tuna!
Everything except eating less meat.
I have a small family, but the water company charges me a minimum amount that is greater than my actual use. i have absolutely no incentive to conserve water.
I use the water to extend my growing season.
increasing water-holding capacity of my soil
making recycling systems more conomically viable
More shade from trees
Natural landscaping
Need more ideas. Already doing those below.
nothing
Planting sage brush and using roundup religiously on everything else
Really? Less meat?!
redusing water while brushing teeth and washing hands
This is for mountain property so I am doing the order as if we're at my home
Using gray water for irrigation

Q14. What is the largest factor(s) that influenced you to begin harvesting rainwater?

Ability to water plants before secondary water is turned on.
bypass ordinance
Cost of water from Orem City
Engineer and like to tinker.
Good discount provided by city
I find it annoying and overreaching for the state to regulate what to do with the water that falls on my property. Since they have allowed me to harvest 2500 gallons, I'll do it so I don't lose that right.
I have not installed or harvested water
I was pissed that the state could mandate home much water I could have from nature, when they do not make the rain. They cannot control when it rains. They should have no right over rain water.
My house is in southern Utah and I'm not always there this waters for me
non-chlorinated water for garden
Only option, no other water sources available
Rainwater has a higher acidity and is very good for a vegetable garden
So I would have the permits before they change the laws again
There is no water in the area and there is no way to purchase water rights. I have no water the only water source is rainwater.
To a secondary source of water because we carry in the water for drinking and other culinary uses
to be able to water my garden on off days of our watering days until my garden takes hold
To facilitate cooling my wine cellar in the winter
To fill in times when secondary water is not available, early Spring and Fall
To have soft water for house plants.
To have water available on a small ag. parcel
to reduce dependence upon municipal water systems
to resolve a water problem
wasting government resources through a pointless permitting system.
We have well problems and our animals are super important to us

Appendix D

Utah State Senate Bill 32

RAINWATER HARVESTING

2010 GENERAL SESSION

STATE OF UTAH

Chief Sponsor: Scott K. Jenkins

House Sponsor: Patrick Painter

LONG TITLE

General Description:

This bill provides for the collection and use of precipitation without obtaining a water right under certain conditions.

Highlighted Provisions:

This bill:

- provides for the collection and use of precipitation without obtaining a water right under certain conditions; and
- makes technical corrections.

Monies Appropriated in this Bill:

None

Other Special Clauses:

None

Utah Code Sections Affected:

AMENDS:

73-3-1, Utah Code Annotated 1953

ENACTS:

73-3-1.5, Utah Code Annotated 1953

Be it enacted by the Legislature of the state of Utah:

Section 1. Section **73-3-1** is amended to read:

73-3-1. Appropriation -- Manner of acquiring water rights.

[~~Rights~~] (1) A person may acquire a right to the use of the unappropriated public

waters in this state [~~may be acquired only~~] only as provided for in this title. [~~No appropriation of water may be made and no rights to the use thereof initiated and no notice of intent to appropriate shall be recognized except application for such appropriation first be made to the state engineer in the manner hereinafter provided, and not otherwise. The~~]

(2) The appropriation of public waters in the state shall comply with the requirements of this title.

(3) Except as provided in Subsection (7), a person obtaining, initiating the use of, or providing notice of intent to appropriate a water right shall comply with the requirements of this chapter.

(4) An appropriation [~~must be for some~~] may be made only for a useful and beneficial purpose[~~, and, as between~~].

(5) (a) Between appropriators, the one first in time [~~shall be~~] is first in rights[~~, provided, that when a~~].

(b) A use designated by an application to appropriate any of the unappropriated waters of the state that would materially interfere with a more beneficial use of [~~such~~] the water[~~, the application~~] shall be dealt with as provided in Section 73-3-8. [~~No~~]

(6) A person may not acquire a right to the use of water either appropriated or unappropriated [~~can be acquired~~] by adverse use or adverse possession.

(7) Notwithstanding Section 73-3-2, a person may directly capture and store precipitation as provided in Section 73-3-1.5.

Section 2. Section **73-3-1.5** is enacted to read:

73-3-1.5. Capture and store precipitation.

(1) As used in this section, "parcel" means an identifiable contiguous unit of property that is treated as separate for valuation or zoning purposes and includes an improvement on that unit of property.

(2) Notwithstanding Section 73-3-2, a person may:

(a) directly capture and store precipitation on a parcel owned or leased by the person in accordance with Subsection (3) or (4); and

(b) place the water captured and stored as provided in Subsection (2)(a) to beneficial use on the parcel on which the water is captured and stored.

(3) If a person collects or stores precipitation in an underground storage container, the person may collect and store precipitation:

(a) in only one underground storage container for a parcel if the underground storage container:

(i) has a maximum capacity of no more than 2,500 gallons; and

(ii) is installed in accordance with relevant building codes adopted under Title 58, Chapter 56, Utah Uniform Building Standards Act; and

(b) after registering for the capture and storage of precipitation in accordance with Subsection (5).

(4) If a person collects or stores precipitation in a covered storage container, the person may collect and store precipitation in no more than two covered storage containers, if the maximum storage capacity of any one covered storage container is not greater than 100 gallons.

(5) (a) The state engineer shall provide a website on which a person may register as required by Subsection (3).

(b) To register, a person shall complete information required by the state engineer including the:

(i) name and address of the person capturing or storing precipitation;

(ii) total capacity of all containers storing precipitation; and

(iii) street address or other suitable description of the location where precipitation is to be captured and stored.

Appendix E

IRB Approval and Permission to Reprint Material

Institutional Review Board

USU Assurance: FWA#00003308

Exemption #2

Certificate of Exemption

FROM:

Melanie Domenech Rodriguez, IRB Chair

Nicole Vouvalis, IRB Administrator

To:	Phillip Waite, David Honaker
Date:	March 22, 2017
Protocol #:	7509
Title:	Understanding Barriers In The Adoption Of Rainwater Harvesting In Utah

The Institutional Review Board has determined that the above-referenced study is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #2:

> Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through the identifiers linked to the subjects: and (b) any disclosure of human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

This exemption is valid for three years from the date of this correspondence, after which the study will be closed. If the research will extend beyond three years, it is your responsibility as the Principal Investigator to notify the IRB before the study's expiration date and submit a new application to continue the research. Research activities that continue beyond the expiration date without new certification of exempt status will be in violation of those federal guidelines which permit the exempt status.

As part of the IRB's quality assurance procedures, this research may be randomly selected for continuing review during the three year period of exemption. If so, you will receive a request for completion of a Protocol Status Report during the month of the anniversary date of this certification.

In all cases, it is your responsibility to notify the IRB prior to making any changes to the study by submitting an Amendment/Modification request. This will document whether or not the study still meets the requirements for exempt status under federal regulations.

Upon receipt of this memo, you may begin your research. If you have questions, please call the IRB office at (435) 797-1821 or email to irb@usu.edu.

The IRB wishes you success with your research.

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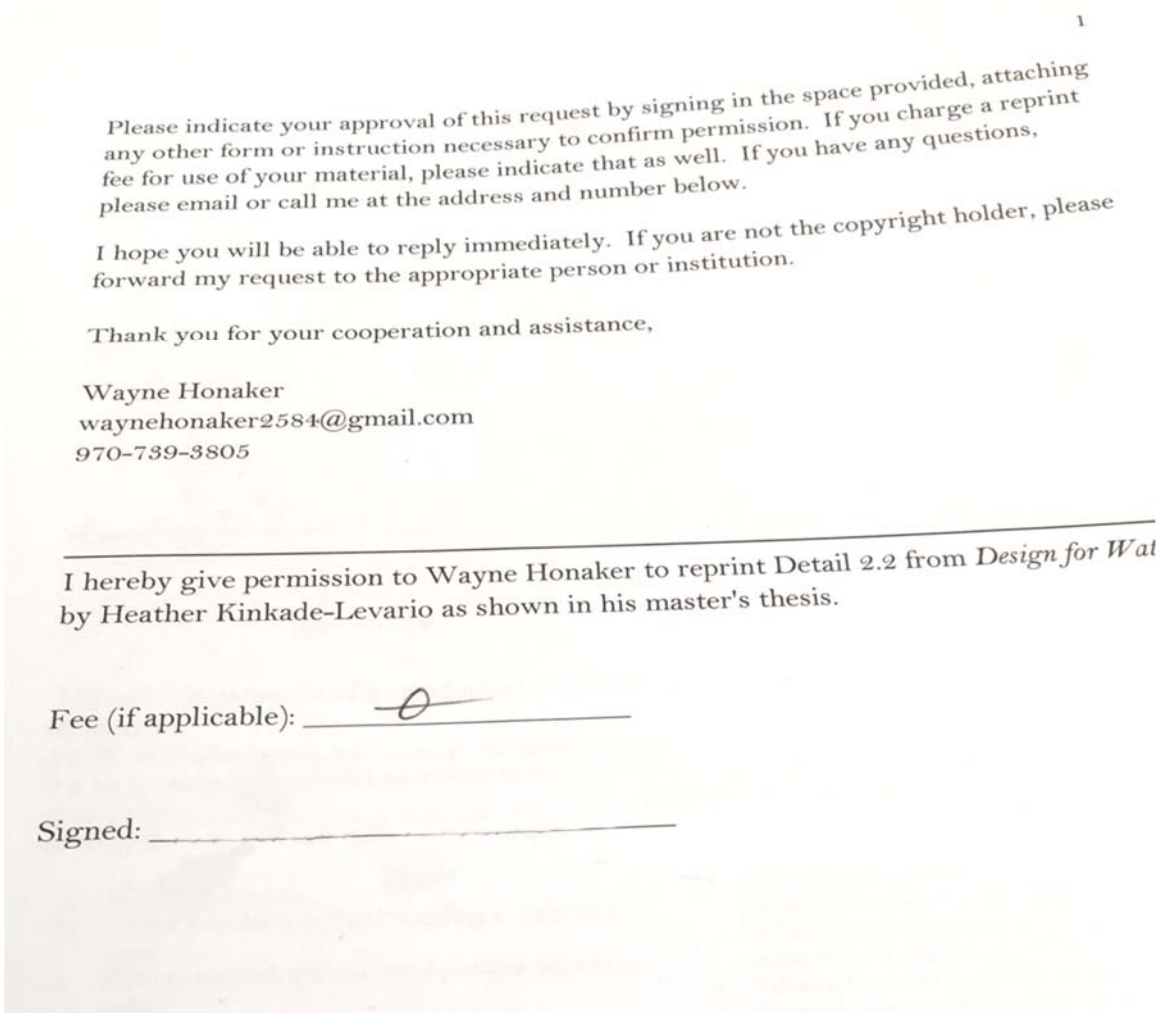

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I hope you will be able to reply immediately. If you are not the copyright holder, please forward my request to the appropriate person or institution.

Thank you for your cooperation and assistance,

Wayne Honaker
waynehonaker2584@gmail.com
970-739-3805

I hereby give permission to Wayne Honaker to reprint Detail 2.2 from *Design for Wat*
by Heather Kinkade-Levario as shown in his master's thesis.

Fee (if applicable): ~~0~~

Signed: _____